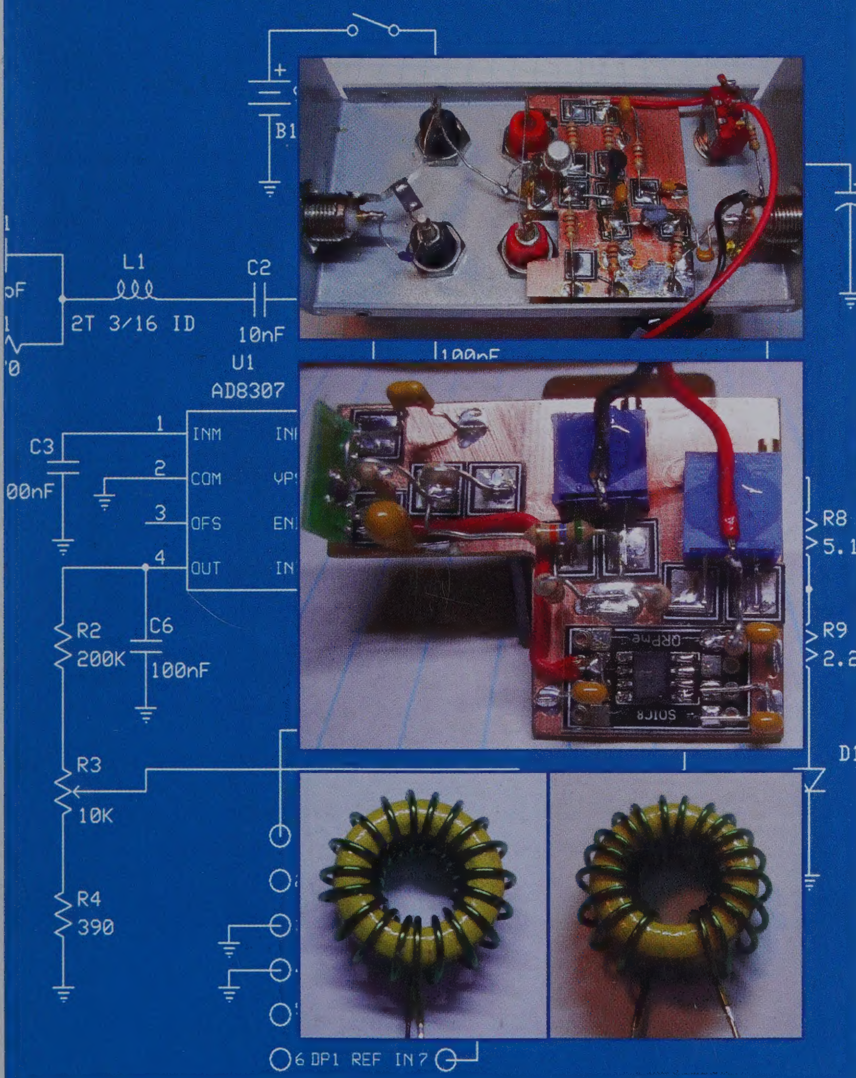
YOUR CONSTRUCTION AND OPERATING QRP SOURCEBOOK

QRP Quarterly

Volume 55 Number 4
Fall 2014

Journal of the QRP Amateur Radio Club International

WD9HNU's L-Q Meter Tests Toroid Winding Methods



- NM4T Tells About QRP ARCI at the ARRL Centennial Convention
- More Arduino Projects from KK6FUT and N6QW
- Sherlock, WØRW, on the Trail of a Failed PRC319
- QRP Contest Results:
  - QRP Shootout
  - Summer Homebrew Sprint
  - Welcome to QRP

QRP ARCI[SM] is a non-profit organization dedicated to increasing worldwide enjoyment of radio operation, experimentation and the formation and promotion of QRP clubs throughout the world.

Table of Contents

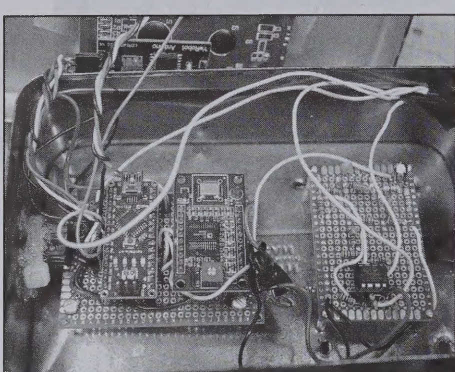
QRP Quarterly
Volume 55 Number 4 – Fall 2014

Technical Articles

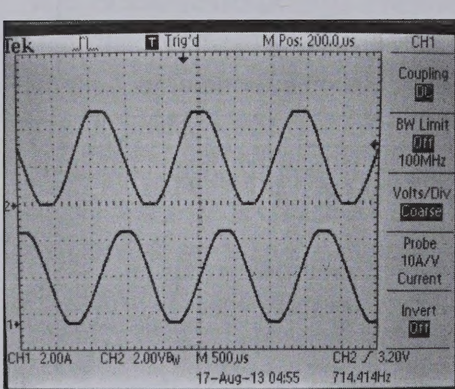
The Joy of QRP

The World of QRP ARCI

page 16



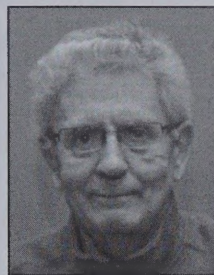
page 33



page 38

Editorial

Tim Stabler—WB9NLZ tastabler@comcast.net



For those who have noticed, my email address has changed, hopefully for the better. In my old email address, 50% or more of the stuff sent to me wound up in "trash" and unless I went looking, I never saw it. I was having some problems with both of my computers and had a local ham look at them. He has put together an 8-core computer for his own work. Since I had just had Xfinity put in my Internet, phone and home security, I had a Comcast account. So I am changing my personal account there. You should use my club e-mail: editor@qrparci.org, for magazine-related business. My ham friend put Windows 7 in both of my machines, which are now working fine.

Also, for anybody who might be looking for pictures from me, you will not be getting anything. My camera "froze" at FDIM, so I went to my local camera shop when I returned to be told new cameras are like computers in that they work when they want to. The camera was working fine then. Until I got to the ARRL Centennial celebration when it decided not to work again. So I returned to my camera shop again really upset. They found a problem which will cost me about $300 to repair. But, at least it can be repaired at much less cost than a new Nikon digital camera.

Now for some apologies. In the Summer issue, I did a write-up of Ozarkcon. After it got out, I had an email from Gary Auchard, WØMNA. I had his name spelled wrong and I apologize for that (as well as for spelling his wife's name wrong!) He also pointed out that his Best of Show award was for his 3 band regen receiver and not the 40 M transceiver pictured. I have included a picture of Gary's rig in my Clubhouse column. Also, in my FDIM write-up, I mentioned that Stan Sindeev, UA3LMR, was not at the meeting but on a DXpedition. Somehow, I added an "a" to his name, to my embarrassment, got his name wrong.

In my mail, I do get "The 5 Watter", the quarterly publication of the Michigan QRP Club. In the Summer issue, the Editor, Mike Hall, WB8ICN, brought up information about a comic book, available on-line, about soldering. The title is "Soldering is Easy, Here's How To Do It." I did download and print out the comic. It is 8 pages long and a very interesting read. If your club is be doing a buildathon and you might get people who know nothing about soldering and this would be perfect for them. Just go to: http://mightyohm.com/soldercomic. Go down the page a little and you will see the site for the download. You will also see that the comic is available in several different languages.

Lastly, several of us get notes from you how much you enjoy this publication. Thank you very much. However, we also get mail asking where are the simpler (and less expensive) projects for everyone to build. We rely on you, the reader, to contribute your stories for each issue. If we do not have it, then it cannot be published. So I am asking that you, the reader, and whatever club you are a member of, to dig out your projects and look them over. If your project fits the bill, write it up and send it in either to me or an associate editor. We will look your project over. If we like it, we will work with you to get it into final form for publication. Then you can tell your friends that you had your project published.

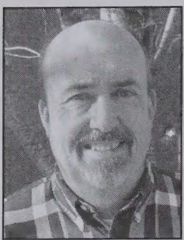
Lastly, Kai Siwiak, who writes our "Ionospherica" articles, would like feedback from any interested reader on the possible content you would like to see from him. Please contact him directly.

Enough for now. I hope everyone has good Fall and Winter seasons!

—72/73 de WB9NLZ

From the President

Ken Evans—W4DU president@qrparci.org



Promoting QRP

The very name of our club indicates the obvious objective of promoting QRP operation. Over the years we have tried various things to highlight the enjoyment that QRP brings to amateur radio.

The first item that comes to mind is the *QRP Quarterly* or *QQ* as it has been dubbed. The magazine is the flagship item of the club in that it passes along the helpful hints and ideas developed across the membership. It is highly regarded as being informative and professional. The web site (http://www.qrparci.org/) is a close second to the *QQ* as it puts forth a public face to club members and non-members alike. Both are a great source of QRP information.

The club also has an excellent awards program. This gives both members and non-members some individual targets. It promotes QRP by providing a motivation to get on the air and demonstrate the possibilities of QRP.

The club also promotes QRP activity through the organizing of QRP contests. These are an excellent ways to demonstrate both the capability of QRP and the fun that can be had by using it. The contests attract people who are new to QRP and give them the opportunity to learn through experience that QRP is a viable facet of our hobby. As of this writing, we have one major contest and two sprints scheduled in the last quarter of 2014. They are:

The Fall QSO Party – 11-12 October
The Top Band Sprint – 27 November
The Holiday Spirits Homebrew Sprint – 14 December

I plan to be active in these contests and ask you to join me in promoting QRP in these events. Information on all the above items is at the club web site.

The final way the club promotes QRP is a physical presence at hamfests. This gives us the opportunity to put faces to the calls and names we read about in the *QQ*, on the web or hear in the contests. The most recent opportunity came at the ARRL 100th Anniversary in July. The club had a table and entertained a constant string of visitors. A number of people joined the club on the spot and went away with a positive perception of QRP.

I mention all this to give you some arrows for your QRP quiver!! When in conversation with QRP skeptics, pass along a copy of the *QQ*, or direct them to the web site. You can also encourage them to shoot for a QRP award or participate in one of the contests or sprints. Getting them on the air using QRP can be the best recruiting tool available. Remember some of the shock and amazement you felt with that first QRP QSO. As has been said a number of times, "The thrill is back".

Finally, if you would like to set up a QRP table at a local hamfest, please let us know. The club has some funding available to assist members in obtaining hamfest space. Literature and some QRP handouts (pens, key chains, etc.) will also be provided.

—72, Ken Evans, W4DU
President, QRP ARCI

QRP ARCI Awards

Julio Jiminez—AK4VL awards@qrparci.org

Greetings QRPers! The last six months have been quite eventful for QRP ARCI Awards, you continue to push the limits of low-power communications. So much so, that I've had to create multi-band QRP DX and KMPW awards all the way up to 10 Bands!

In this issue of the *QQ*, I would like to officially announce the QRP ARCI Awards online submittal system. Simply go to **http://awards.julioj.com** and submit your application for all major QRP ARCI awards. New features for this web application are still in the horizon, such as, multiband versions of the KMPW, QRP DX, QRP WAC, and QRP WAS, among other back-end improvements.

Just like we did with the GCR form, awards requiring log certification by two other hams can be done within the user interface. In fact, at the time of this writing, we had 104 registered users, so logs get certified rather quickly.

Oh and don't worry, you will still get an award in the mail, printed on fancy paper, with the official QRP ARCI gold seal. Thanks for reading!

—72 de AK4VL
Julio Jimenez

●●

QRP ARCI Website

QRP ARCI Awards, Contests, Toy Store, FDIM hotel and program and much more information can be found on the club website. It's also the place to join or renew your *QQ* subscription.

Be sure to check www.qrparci.org often for the latest news on club activities and the larger world of QRP!

www.qrparci.org

Idea Exchange

Technical Tidbits for the QRPer

Mike Czuhajewsi—WA8MCQ wa8mcq@verizon.net

In this edition of Idea Exchange:

Alex's Little Helpers

Joe Everhart, N2CX, presents #91 in the endless series of Technical Quickies he promised me 2 decades ago—

The PY1AHD Alex Loop, currently available as the Walkham Loop™ [Ref 1, 2, 3] is very popular and handy for portable QRP operation. Figure 1 is a snapshot of the 3 foot diameter loop. I particularly like it since it can be set up easily and quickly and is not nearly as intrusive in public parks, etc., as the usual wire or vertical antennas. It's hard to beat on 20 meters and above, although I've had only limited success on 40 meters and the jury is still out on its effectiveness on 30.

There are several issues that need to be addressed to use it, however. First is mounting. It comes as a handheld antenna, which makes it awkward for extended operating periods, especially on CW. The second is its inherently narrow tuning range. Directions on its use recommend that it be tuned for maximum received noise on the band used. However the tuning is very sharp and it has a 2:1 SWR bandwidth on the order of 10 kHz on 20 meters and less on 30 and 40. In addition, many rigs require an SWR of 2:1 or less or the transmitters will shut down. Peaking on noise does not ensure that tuning is within that range.

Let's look at mounting first. Using it handheld means slipping a bicycle handgrip over the six-inch bottom end of the vertical mounting pipe. The handiest way to support the loop is to mount it vertically on a tripod or other structure, somehow attaching this six-inch pipe end. There are various ways of doing this although many require special fixturing.

Probably the most common is to build an insert that slips inside the loop handle and screws onto the 1/4-20 screw on a common camera tripod. In fact, AD5X has come up with a simple adapter using inexpensive hardware available from your favorite hardware megastore [Ref 4]. I built one and tried it quite successfully, but I felt that it had several shortcomings.

It is handy for quick setup but I find that the 3 foot lever arm on the small friction-locked tripod mount tends to come loose over time and the loop tilts sideways. Second, the three foot lever arm on a short 1/4-20 screw puts lots of stress on the latter. In fact, my friend George, N2APB, found that the loop broke the metal clad plastic mounting screw on his economy tripod.

I bought an up-scale, rugged tripod (Sunpak 6601 2-in-one tripod/monopod) from Walmart that featured a monopod that could be removed from the tripod base. I hoped that the loop pipe end would fit inside the tripod hole (Figure 2) vacated by

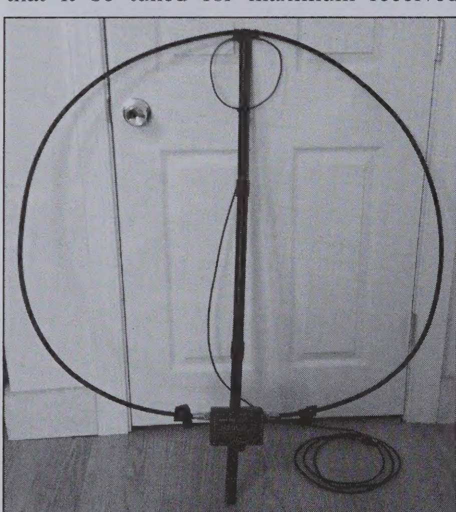


Figure 1—The Walkham Alex Loop.

Figure 2—Hole in the Sunpak tripod for the monopod.

Figure 3—The loop is attached to the tripod with PVC pipe.

the monopod. Unfortunately the pole outer diameter was an inch while the tripod hole was a measly 1/16 inch smaller. What I decided on was adding a smaller diameter section of PVC pipe that would fit into the hole and then strap the loop pole onto this pipe.

A piece of 1/2-inch Schedule 40 PVC water pipe fits the bill (Figure 3). A 53 inch length of it sits in the tripod and leaves enough extending out the top to fasten the loop securely. The bottom of the pipe sits on the ground (add a pipe cap) and, with the support of the tripod, makes a good secure mount. [*WA8MCQ note—"1/2 inch" is a pipe size designator and not the actual outer diameter, which is somewhat more than that.*]

Note that I've cut the PVC support pipe and spliced it together with a pipe coupling below the tripod. No glue is used, so it can be taken apart easily. This makes the disassembled lengths short enough to fit into the tripod box for easy transport.

The top of the PVC pipe is attached to the loop mast with some plastic cable ties (Figure 4). You can either use ordinary ties to mount the loop or, as I've done, get some reusable ties [Ref 5, 6]. While the reusable ties are not quite as strong they are adequate and eliminate the need to carry extras while portable.

WA8MCQ notes—The only loop antenna I have any experience with is the fairly heavy MFJ tunable loop which I used briefly at a previous job and I knew absolutely nothing about the Alex Loop. I asked Joe how robust the cable ties are and whether they were strong enough to be trusted. His reply: "The ties are entirely adequate when you use three of them as I

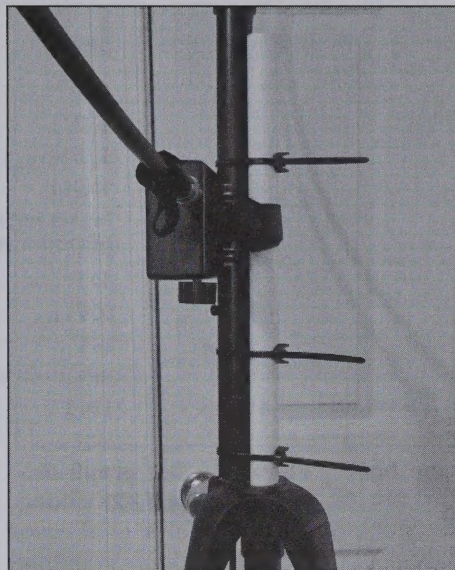


Figure 4—Close-up of loop mounting with cable ties.

did." (I later found out that the Alex Loop is considerably lighter than the MFJ and only weighs around 3 pounds vs. about 20.)

I also wondered aloud if worm-drive hose clamps (commonly available in automotive and hardware stores) would be better since they are metal and stronger, but Joe pointed out that they would effectively be shorted turns in close proximity to the loop. I don't know how much effect they would have since they wouldn't be in the same plane as the loop and probably have less than ideal coupling, but still it can't be a good thing and I wouldn't recommend it. (This sounds like a good experiment for someone with a loop, to see how much difference there is in using the metal clamps instead of plastic ties.) *—MCQ*

As mentioned above, tuning the Alex Loop is a two-step process. First, it is tuned for maximum received noise at the operating frequency to get it in the ballpark. Second, it is tuned for lowest SWR while transmitting. This works well with my KX3 which has a built-in SWR meter and can withstand high SWR during tuning, but many rigs do not have the metering capability and may balk at an SWR over 2:1 or so.

My answer to this is to use an SWR meter that incorporates a resistive bridge to limit SWR and has a handy analog-ish display. The bridge limits SWR to no more than 2:1 while tuning and the display makes adjustment quick and easy. Utilizing an analog type display is best since it is much easier to null SWR with an analog indication than trying to interpret a digital display.

One could use the Tayloe SWR bridge [Ref 7] which shows lowest SWR by dimming of an LED. However, being rather OCD about such things, I like to know the actual SWR with some certainty. N2APB and I designed just such a bridge a couple of years ago called the Growler [Refs 8, 9]. Figure 5 is a photo of the board while Figure 6 is the schematic diagram.

Operation is fairly simple. It is placed in-line with the feedline between the transmitter and loop and the power. When the unit is turned on and the transmitter enabled (continuous carrier) it emits a pulsed audio tone whose pitch varies with the measured SWR; the tone decreases with lower SWR and increases as SWR goes up. In addition, multicolored LEDs illuminate to give a visual SWR display. The operator simply tunes the loop for

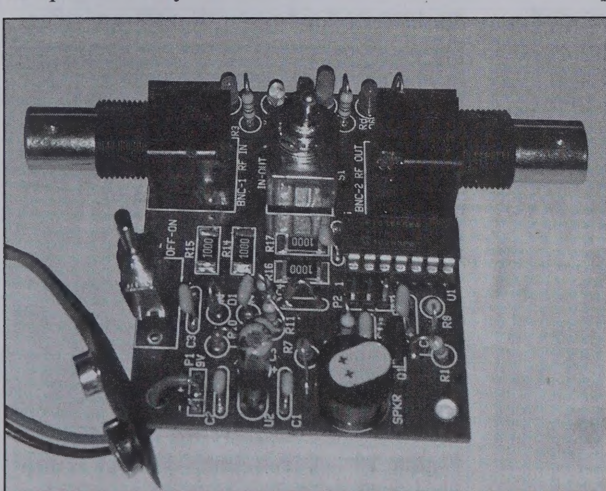


Figure 5—The Growler board.

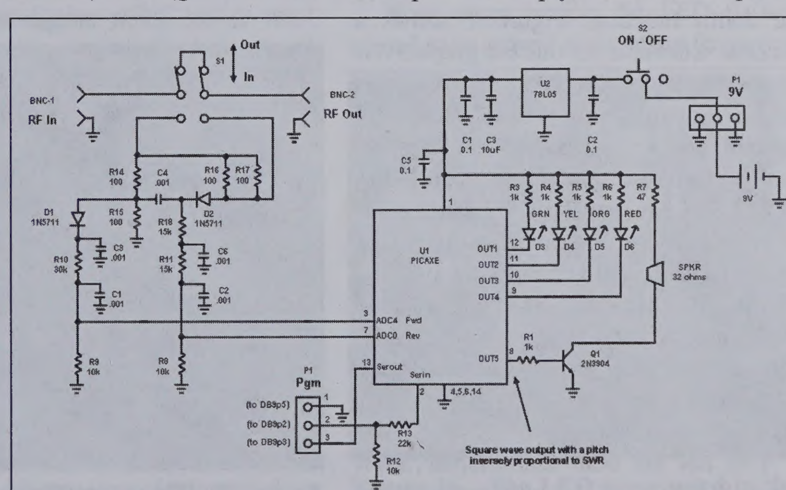


Figure 5—Schematic of the Growler. (See text about R14 and R15.)

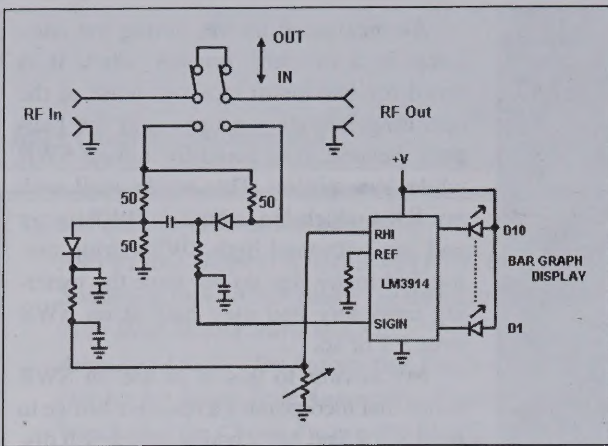


Figure 7—Notional schematic diagram of the bar-graph SWR indicator.

# of LEDs	SWR
0	1:1
1	1.2:1
2	1.5:1
3	1.9:1
4	2.3:1
5	3:1
6	4:1
7	5.7:1
8	9:1
9	19:1
10	>19:1

Figure 8—Bar graph display SWR vs. LED values.

lowest readings. When the carrier is removed, the Growler sends an audible Morse reading of the final SWR value. Though not available as a kit, there is enough information available in the references to duplicate the project.

WA8MCQ note—The resistors at R14 and R15 are usually 50 ohms, as in Figure 7. (The R16/R17 parallel pair also uses 100 ohms, but the net value is 50.) Joe said that the Growler used 100 ohms in an attempt to minimize heating since surface mount resistors were used and that, operationally, all it really affects is the maximum SWR with an unmatched load and does not affect bridge operation. In this case the maximum would be 4:1 instead of the usual 2:1 when 50 ohms is used. He recommends above that the SWR be limited to 2:1 and said his intention is to revise the R14 and R15 values to 50 ohms each

A simpler indicator can also be built by using a bar graph display and eliminating the audio function. Figure 7 shows a notional schematic for this bar graph SWR meter. The usual resistive SWR bridge is used along with simple diode detectors for forward and reverse sampling. The forward and reverse samples are then fed to an LM3914 bar graph IC. The latter compares the two and illuminates 10 LEDs according to the ratio between the two. All 10 illuminated means that the measured SWR value is very high and lesser values light fewer of them until all are dark for a 1:1 SWR. Figure 8 is a table of SWR versus LED illumination.

I've not yet built this simpler SWR meter but it is in the works. Since the bridge and diode detectors are already proven and the "heavy lifting" is done by the LM3914, no major problems are anticipated once the unit is built and tested.

References

1. PY1AHD Alex Loop site: www.alexloop.com
2. I got my loop from HRO: http://www.hamradio.com/detail.cfm?pid=h0-012701
3. Another source is W4RT: www.w4rt.com/Misc/alexloop.htm
4. Loop tripod adaptor: http://www.ad5x.com/images/Articles/WalkHam%20Tripad%20Adapter.pdf. Note that the URL misspells it as "tripad"
5. SOTAbeams reusable wire ties: http://www.sotabeams.co.uk/reusable-cable-ties-pack-of-10/
6. Home Depot reusable wire ties: http://www.homedepot.com/p/Gardner-Bender-8-in-Black-Releasable-Cable-Ties-10-Pack-296184/202520077
7. Tayloe SWR bridge: www.qrpkits.com/swrindicator.html
8. Growler session of CWTD (Chat With The Designers) http://www.cwtd.org/Feb%2028.html
9. YouTube video of early Growler prototype: www.youtube.com/watch?v=2JJ9o1GDrGM

—de N2CX

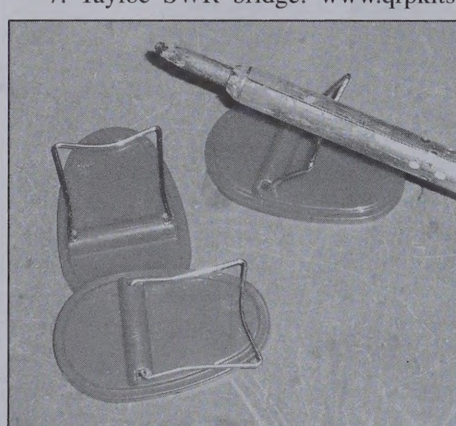


Figure 9—Three plastic-and-wire soldering iron stands.

Soldering Iron Stands Make Lightweight Bails

From Bryant Julstrom, KCØZNG—

A bail is a support at the front of a piece of equipment that tilts the unit so that its controls are more accessible and its panel is easier to see. Flip-up bails are built into many electronic devices, and in the Winter 2010 issue of this magazine WA8MCQ passed along a suggestion from KG6MFT to use handles as fixed bails on units that do not have them.

Soldering iron stands can also be repurposed as simple, economical bails. These stands consist of a plastic oval and a metal loop; when the loop is flipped up, the stand can hold a soldering iron more or less safely, as Figure 9 illustrates.

To make a bail for a piece of electronic equipment, attach two of these stands near the front of the unit's bottom. A pair of small bolts is sufficient for each stand. Flip up the wire loops, and the unit is at a convenient height and angle. Figure 10 illustrates this arrangement on a homebrew frequency counter.

There are undoubtedly several versions of these stands. One is available from The Electronic Goldmine (www.goldmine-elec.com), part number G17049. These devices are not sturdy, so this arrangement works only for smaller, lighter equipment.

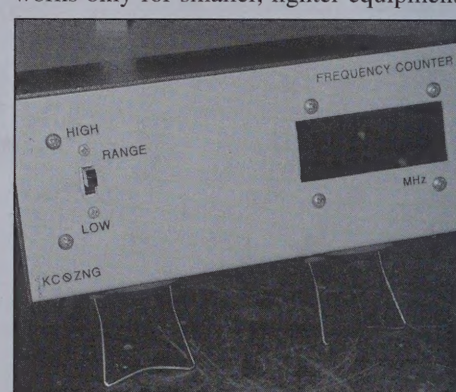


Figure 10—A frequency counter is supported by bails made from two soldering iron stands.

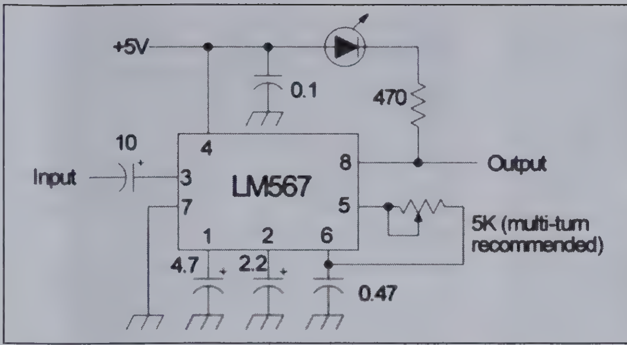


Figure 11—A tone detector with an LED makes a zero beat indicator.

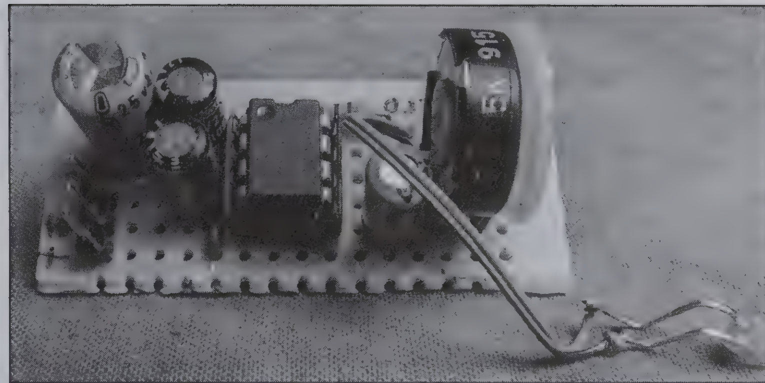


Figure 12—The tuning aid is built on a small piece of perf board.

To avoid cracking, the plastic should be supported at the bolts with washers or grommets. To provide more grip, heat-shrink tubing or tape could be applied to the metal loops on the stands. If you'd like, paint the plastic parts another color.

WA8MCQ note—At time of writing, these soldering iron stands were on sale for 49 cents each. At that price I wouldn't expect them to be made of high temperature plastic, so it's probably not a good idea to let a hot tip contact them directly. Those without Internet access can request a catalog from The Electronic Goldmine, PO Box 5408, Scottsdale, AZ 85261.

—de KCØZNG

Zero Beat Tuning Aid

Although the idea of using a tone detector for a zero beat indicator has been around for some time, this is one of those classic things that deserve to be described again every now and then for benefit of the newer folks. This is from Howard Zehr, K4LXY.

For my 70th birthday this summer, my wife gave me a TEN-TEC Rebel 506 QRP transceiver. The Rebel is unique in that it is built around an Open Source Arduino-compatible controller. Both hardware and software are intended for user customization and I'm having great fun tweaking it.

The Rebel has a slightly higher than normal sidetone and frequency offset. Since I am not used to this and don't have perfect pitch, I've found it hard to precisely land on the frequency of the station I want to work. I needed one of those "tuning eyes" they used to put on radios in the 1950s! Actually, a beat indicator isn't a new idea in amateur radio, but I couldn't seem to find any modern circuits. After considering various options, on the way home from a NAQCC (North American QRP CW Club, http://www.naqcc.info) outing in the Virginia/West Virginia mountains, my friend Russ K3NLT, suggested a tone decoder.

I settled on the tone detector circuit based on the LM567 and described on this website:

http://www.scary-terry.com/more_stuff/tonedet/tonedet.htm

Figure 11 shows the circuit as built. The only change was the capacitor on pin 6; I had to raise the original value to get this into the audio frequency range I wanted, which I did by experimenting. The LED lights when I have hit the frequency I want, so that is the only output I needed. (*WA8MCQ note—be sure to use a high quality capacitor to minimize drift issues.*)

I didn't have a multi-turn 5K potentiometer and so used a small one from the junk box. A multi-turn one would it make it easier to adjust precisely, however.

Using a small piece of PC perf board, I built a compact unit that I could mount inside my rig. Figure 12 shows the board and Figure 13 shows it in place in the radio.

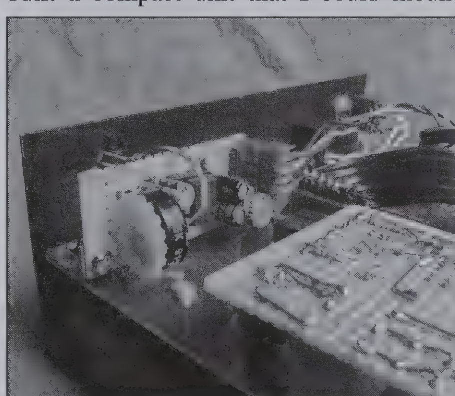


Figure 13—The tuning aid installed in the Rebel.

Rather than drill a hole for the LED that serves as indicator, I used one that was already there. The TEN-TEC folks have cleverly built an LED into their logo on the front panel, as shown in Figure 14. Because the Rebel doesn't come with an LCD readout (that's one of the projects for users), the LED is designed to flash each time one moves the dial a specific frequency unit. I've added an LCD display so didn't need that LED, and it makes a perfect tuning aid.

The unit is calibrated by adjusting the potentiometer. You could do this by using a frequency generator or even by ear to match the sidetone. However, I have an audio frequency counter app on my iPhone and that did the trick nicely. Mine seems to be accurate within about 5% or better.

This indicator can be built small enough to fit into many rigs, but it could also be a separate unit or even built into a speaker.

Now, when tuning, the LED flashes when I have arrived at my offset frequency

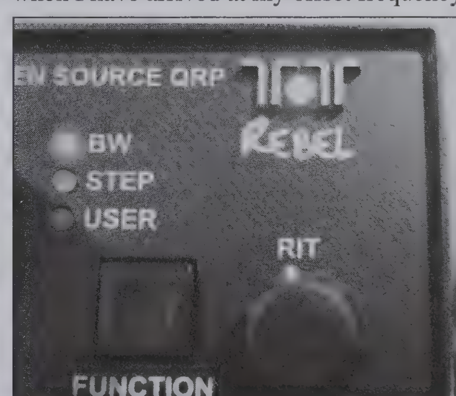


Figure 14—The LED is mounted in the existing hole in the front panel logo.

and I am aligned with the other station. No more guessing.

WA8MCQ notes: The LM567 is still available, stocked by Mouser and DigiKey, under $2 each, in both DIP and SOIC packages. It is currently made by TI and you can find the data sheet on their web site at www.ti.com. (The NE567 is an older version.)

—de K4LXY

Ammeter Adapter for Automotive Fuses

Low voltage fuses with blade terminals (Figure 15) have been used in automobiles for a very long time, and they are also handy at home for a variety of low voltage DC uses, such as rechargeable batteries powering QRP rigs. Here is a handy way of using the fuse holder to measure the current flow, from John Rusmiselle, KG4VHV—

I needed a way to take current readings on my batteries and didn't want to make up an adapter with a couple of Power Pole connectors. I thought about it and came up with this.

I had a blown fuse so I took a knife and split the plastic away from the spades. I cut off the remains of the blown fuse link between them. Then I took a jumper cord which has banana plugs that fit my meter and cut it in two.

I soldered the ends to the two spades and covered it with a thin layer of hot glue to hold it all together (Figure 16). If you allow the glue to get too thick it will not fit into the molded fuse holders. Figure 17 shows the complete assembly.

To use, pull the fuse out and plug in the adapter, then configure your meter to measure DC current and plug into the appropriate jacks to read the current draw (Figure 18).

WA8MCQ comments—If you don't have a banana plug jumper to sacrifice, use any suitable insulated banana plugs and insulated stranded wire that is heavy enough to carry the highest anticipated current. As with any current measurement, be sure to observe the limits of your meter. If measuring something that might draw more current than it is rated for, it can blow the fuse in the meter and they are not cheap to replace. For example, in my Fluke 77 the high current input is marked as 10A but is protected by a 15A fuse. Unfortunately

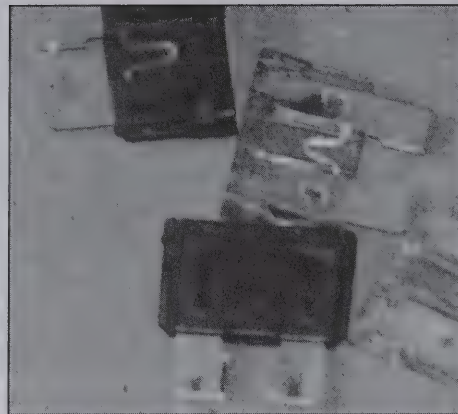


Figure 15—Common automotive fuses.

it's rated at 600 volts and costs from $9 to over $24 each, depending where you get it.

Finally, if tempted to use this for long term monitoring, don't forget that the line is improperly fused as long as the adapter is in the fuseholder. The circuit is still protected by the fuse inside the meter, of course, but there's a good chance that it is a much higher value than the fuse you would normally use. You may have intended for it to be used with a 3 amp fuse but now it has a 15 amp fuse instead. *—MCQ*

—de KG4VHV

Holder for Blade Style Automotive Fuses

Although this type of fuseholder is available in automotive supply stores and the automotive section of places like WalMart, there are many reasons why someone might want to make their own from materials on hand. Here's how John Rusmiselle, KG4VHV did it—

Every now and then I find myself in need of a holder for low voltage, blade style automotive fuses and, being between hamfests, something had to be done. I have seen fuses held by two stake-on connectors but wanted something that worked better

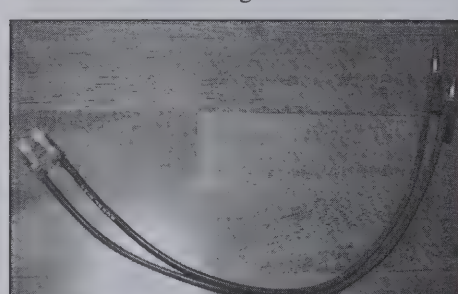


Figure 17—Completed current metering adapter.

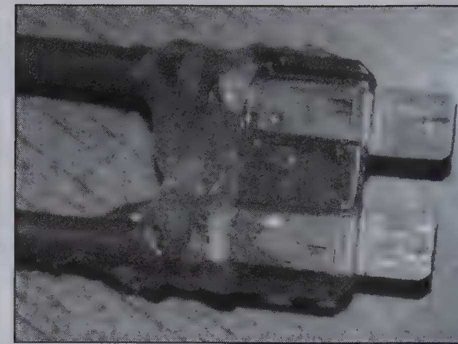


Figure 16—Cut away some plastic, solder wires on and cover with a thin layer of hot glue.

and thought of an easy solution.

Figure 19 shows some of the things I used to make my own holder, including insulated stake-on connectors; there are a few of them to the left of the pair of scissors. Crimp the insulated connectors to the ends of the wires where you need a holder and insert a fuse to hold them in position (Figure 20). Next, cut a piece of card stock as wide as the length of the connectors and long enough to wrap around both of them while the fuse is plugged in.

Heat up a hot-melt glue gun while placing the connectors and fuse in the center of the card with the edge of the card stock even with the top of the connectors. Put hot glue between the connectors and on the edges (Figure 21). While the glue is still hot, roll up the card around the connectors and place a small piece of tape over it to hold it together.

Now fill the end with glue up around the wires until it is slightly mounded (Figure 22). Wait until the glue has cooled,

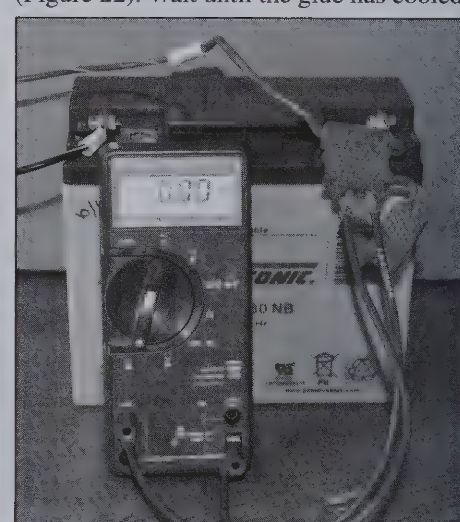


Figure 18—The meter adapter plugs into the fuseholder to measure current draw.

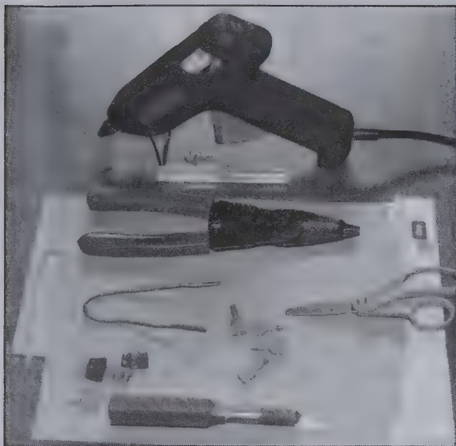


Figure 19—Some of the things used to make a holder for automotive blade style fuses.

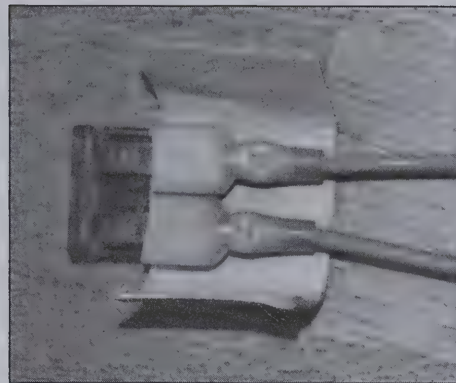


Figure 20—Crimp terminals onto the wires and cut a piece of card stock to wrap around it.

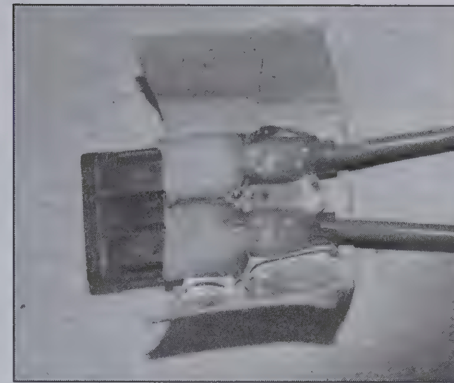


Figure 21—Start adding glue to the assembly.

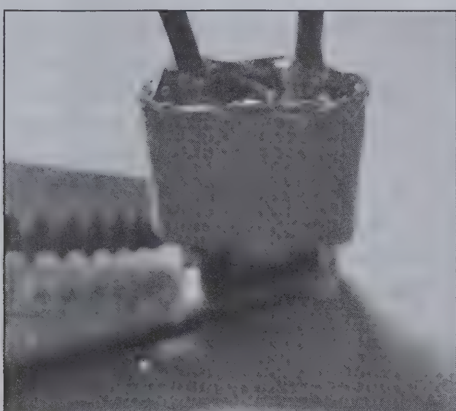


Figure 22—After taping it shut, fill to the top with glue.

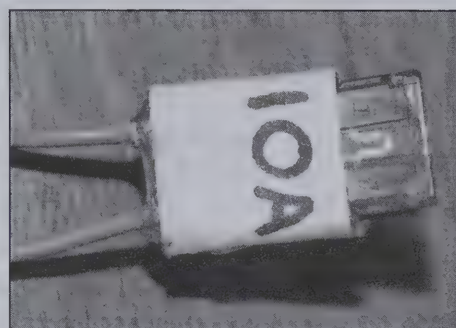


Figure 23—Write the value of the fuse on the holder (optional).

Figure 24—Business (socket) end of the holder.

then take a marker and print the value of fuse on it (Figure 23) and you are good to go. Figure 24 shows the business end of the holder.

—de KG4VHV

WA8MCQ comments—As I said earlier, there are many reasons why someone might want to make their own from materials on hand. You might not want to wait for stores to open, they might be too far away, etc. And a pair of connectors is much cheaper than the $3.49 I paid for one brand-name fuseholder at Advance Auto (Figure 25). Finally, as one of my advisors said, it's true to the homebrewing spirit.

If anyone wonders whether those crimp-on connectors are suitable for use with blade type fuses, I looked inside the fuseholder I bought and it looked almost identical to Figure 24.

I do have some reservations about a homebrew fuse holder due to possible safety and liability concerns, especially since the materials are not nonflammable. A lesser concern is that if current is really heavy the glue could melt and run out. But although it would make a mess, the connectors would remain on the fuse and everything is still insulated so that's not a big deal. As for the possibility of fire, if it's a severe overload and runs very hot the fuse will probably blow long before the wires get anywhere near hot enough to ignite the card stock or glue. (This presumes that the fuse will blow when it's supposed to; more on that later.)

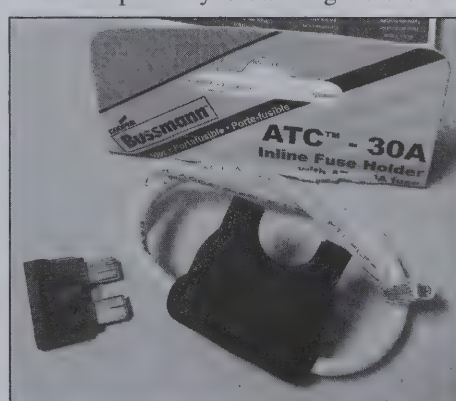


Figure 25—Fuseholders are readily available in automotive parts stores and other places. (This one even included a 30A fuse.)

Be sure to use insulated terminals only, and use only on low DC voltages; this type of fuse is only rated to 32 volts. (Don't even think of using them on anything higher, regardless of the fuseholder. Using a fuse of any type at a voltage above its rating is always a dangerous thing.)

I ran this one past 4 of my advisors, all experienced electrical engineers. A common comment was that this should probably only be done as a temporary measure, and be replaced with a "real" fuseholder when one can be obtained.

One indicated that if he did this he might use something stronger and more heat resistant such as epoxy. (The 5 minute type should be acceptable.) Two of them suggested using a piece of heat shrink tubing instead, which is far less flammable than any card stock. Another said, "My take is that it would be fine, as long as it's not being used for a 'mission critical' application like an automobile, space shuttle, etc. True to the homebrewing spirit.

But even if just for radio use, I'd recommend changing it out when he does get to a hamfest or Home Depot/auto store."

While we're at it, be sure you only use fuses from reliable and reputable sources for everything you do. I've seen occasional horror stories in online forums about "bargain" fuses of various types that blew at much higher currents than they were supposed to, and sometimes didn't blow at all even under extreme overloads. We use fuses to protect things but they only do that if they blow when they should. (See the following article.)

Final comments: I agree that this should probably only be done as a temporary measure. (I still think it's a really good idea, though.) The author and *QRP Quarterly* assume no responsibility for anything that might happen if you do this yourself. Although probably reasonably safe, as with just about everything in homebrewing the builder has ultimate responsibility for staying safe. *—MCQ*

Watch Out for Cheap Fuses

This originally appeared in the Winter/January 2008 issue and is worth repeating:

There were some stories floating around the Internet in late summer of 2007 telling about some inexpensive aftermarket automobile fuses that were defective and not properly protecting against overloads. There were reports of wiring harnesses in some GM cars being cooked because these fuses did not blow when there were shorts. A particular retailer was cited as the source of the fuses; if you really want to know who the retailer was you can look it up on the Internet, but defective fuses could turn up anywhere and they wouldn't necessarily be automotive fuses.

The next time you think about buying fuses of any type, keep in mind that this is not a purchase where you want to cut corners. Remember that the purpose of a fuse is to act as insurance and protect something of value; it would not be prudent to save a few dollars if something expensive would be put at risk unnecessarily. You should only buy fuses made by well known manufacturers, and preferably from well known retailers. This is not a good time to be on the prowl for a bargain.

There are also the issues of counterfeit parts, which appear to be the genuine article but are not, or legitimate but poorly made ones which were supposed to be scrapped but were somehow siphoned off by unscrupulous individuals. This applies to quite a few different kinds of products. We were bit by that a few years ago at work when buying some hard to get parts and an engineer went through a broker of some sort instead of our usual sources (which could not supply it). I don't know if they ever found out whether they were well made counterfeits or legitimate parts that were quality control rejects and should have been destroyed but somehow made it to market. In any case, they had very poor performance.

Fortunately, no damage was caused and the quantities were relatively small, although they were rather expensive parts so the company had to eat a certain amount of loss. (You might occasionally see letters warning about counterfeit parts on some manufacturer web sites, such as Mini Circuits and Micrometals.) As always, caveat emptor when you stumble across what appears to be a great bargain.

—de WA8MCQ

New Product Announcement

Portable specialists SOTABEAMS have just announced an exciting new product. The SB6 is a lightweight portable beam antenna for the six metre band that has been produced in response to customer demand. 50MHz is a great band for portable operating; it supports so many different modes of propagation that results are often surprising, with some amazing DX being possible.

The SB6 has been designed to be very quick to set up and use, with assembly taking less than 90 seconds. As it has been designed for portable use, the packed-length and weight are low at 55 cm (22 inches) and 700g (1.54 lb). The SB6 has a calculated gain of 11dBi and front to back ratio of 24dB when mounted at its design height of 4 metres above ground level. The SB6 has been tested in contests and is a proven performer.

Details at http://www.sotabeams.co.uk/sb6-6m-ultra-portable-beam/

The Fine Print

Finding and starting a new job helped keep the Idea Exchange a bit small this time, along with not having as much material as usual. You can help with the last part—send your ideas and projects to Severn any way you can get it here (e-mail, snail mail, 3-1/2" floppy, CD, handwritten on a napkin, etc), or tell me where you found something of interest on the Internet.

Well written, Pulitzer Prize quality articles are nice, as are computer drawn schematics, but don't worry if you can't do all that. We'll take care of the rest, editing, redrawing, etc. The readers are waiting!

Out and About with QRP

Craig Behrens—NM4T craigb44@msn.com

Chaos, Two Days in Huntsville, Monte Sano Adventures, NoGA meeting and Coming Attractions

Can you imagine a life that is normal? (And, would that be any fun?)

I hear that some folks have balanced lives. Can this be true? Or is this just another urban myth? Most people I know seem to always stay busy. Others seem to live frenetic lives that appear to be totally out of control. At the moment, I'm assessing where I fit into this spectrum of lifestyles.

As an example, the type AAA's among you already have alarms going off. These sense that there is no telling where this column is going—should I stop reading now and run off to my next action item!

However, I will suggest that this is good time to simply stop… Take a nice, slow and deep breath… Settle into your favorite chair and prepare yourself for a fun ride.

Speaking of angst, my anxiety started to build with the ARRL Centennial Convention. Don't take me wrong, it was great, really special and something well worth experiencing. The ARRL certainly did a bang-up job! I felt honored to be selected to present one of their forums. But, this was also another major activity to support in an already busier than usual hamfest year. And I was driven to do something really special for this once-in-a-lifetime event.

Because this was such a special event, the QRP ARCI staff decided that this would be a good time to create a new club banner to be used at such functions. So, my oldest daughter, Kim (the graphic designer pro) and I got to work. After several reviews and collaboration with the ARCI Staff, we managed to get these delivered just in time to hand-carry to the Centennial Convention. Figure 1 shows the horizontal version used at our booth and Figure 2 shows the vertical version that comes with its own portable stand. We used it at the Huntsville Hamfest QRP ARCI booth.

(Please note that we have 3 of these special banners available for use at the hamfests and other special events that our club supports.)

Figure 1—QRP ARCI Booth at the ARRL Centennial Convention.

Getting back to forums, ARRL's notorious QRP aficionado Ed Hare, W1RFI was tasked to select and implement two forums that focused on QRP. So, Ken-W4DU presented an improved and updated "Why QRP" forum to a full room of around 100 people.

Figure 2—QRP ARCI banner.

Glen, KW5GP and Craig, NM4T presented the second forum, "When Worlds Collide: The Blending of the Maker, Survivalist and Amateur Radio Cultures." We presented real life examples of how people from all walks of life are joining forces to cross traditional product application and cultural boundaries with new enabling technologies. (We also had standing room only.)

In addition to discussing the special activities that create such cross-cultural opportunities—we revealed a number of actual design examples and spent time looking at how they are already redefining our future lifestyles. Then, we wrapped-up the forum speculating as how amateur radio must morph to serve new, evolutionary needs of QRPers, Makers, Survivalists and others as they unite to create a brave new world, a brighter tomorrow.

So that was it for July.

August was all about making the Two Days in Huntsville (TDiH) forums for the Huntsville Hamfest's QRP forum track. As is our tradition-all seven forums were brand new and were presented by noteworthy speakers (celebrities). Since the vast majority of the *QQ* readership can't attend TDiH, I will briefly summarize these and what their goals were.

Jim, W4QO was tasked to kick-off the QRP forum tract, to get the gang excited, sufficiently stirred-up. Attendees were having a lot of fun with his very special version of "Why QRP?" (Figure 3), which

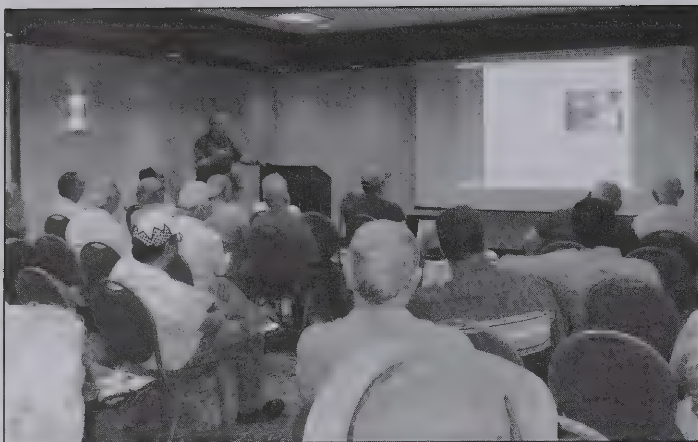


Figure 3—W4QO shares how QRP can impact your life.

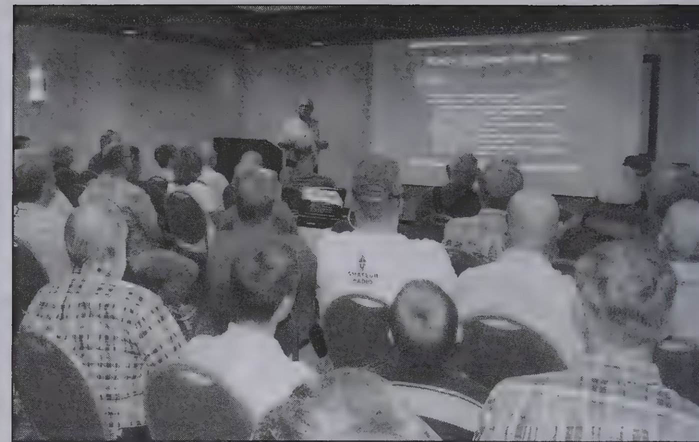


Figure 4—KW5GP and 'What a Difference a Year Can Make.'

Figure 5—Record TDiH forum attendance.

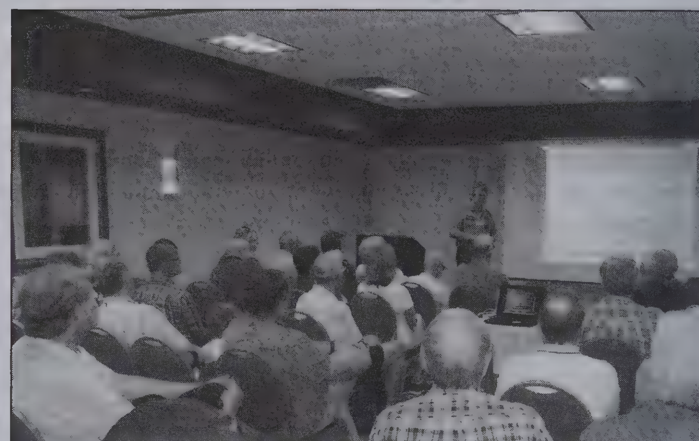


Figure 6—John Henry and 'TEN-TEC's Vision'.

includes many examples and colorful tales as to how becoming a QRPer will change your life and bring many new adventures your way.

Next, Glen-KW5GP presented "Arduino and You: Let the fun begin!" (Figure 4) to the hard-core Arduino fans and newbie hopefuls. He started by reminding those that attended last year's (our first) Arduino forum about what we discussed there. Then he lead us through the many adventures that brought us to the present introduced us to some of the new opportunities that await us now.

As a side note-we had record QRP forum attendance (Figure-5) with standing room only (100+ people) and some people not able to get into the room for a couple of the forums. (The Huntsville Hamfest staff has committed to providing us with a bigger conference room for next year.)

Our third forum, "Understanding & Customizing Arduino-Based Transceivers", (Figure 6) featured John Henry, KI4JPL and Glen, KW5GP. They took turns showing how QRPers are taking open source and ham radio to the next level. John discussed TEN-TEC's vision, design philosophy and inner workings of Arduino-based transceivers. He explained the Model 506 Rebel and its brand new CW/SSB/Digital mode brother, the soon to be shipping Model 507 Patriot transceiver.

Our fourth and final Saturday forum was "Hybrid Portable Antenna System Design, Featuring Buddipole Antennas" (Figure 7). Chris, W6HPF and Craig, NM4T show you how commercially manufactured antenna systems can be optimally used in field operations and how they can be "souped-up" to provide much higher levels of performance by applying a little antenna design "magic."

We started Sunday's forums with "The Indirect Method of Measuring Coax and Tuner Loss" presented by Dr. John, N5DF (sorry no picture available). John showed us better and more practical methods for accurately measuring coax and tuner losses. Further, he quickly walked us through the derived formulae that predicts the measured results.

Our sixth forum was "Working the Modes, QRP Style" (Figure 8) presented by Rob, KB5EZ and co-authored by Greg, N4KGL. We created this forum because most of us don't know how to operate all modes in the field with modest station setups? And, QRP is so much more than just CW, you know! Rob showed how we do multi-mode SOTA and RaDAR operations outdoors. Further, he provided examples for how you can leverage new technology and operating techniques in your next portable and/or emergency field operations. Besides FM, CW and SSB overviews-this presentation provided a special focus for operating the digital modes, RTTY, PSK-31 and JT65—yes, in the field.

NM4T presented the ARRL Centennial Convention forum, "When Worlds Collide", discussed above as our final Two Days in Huntsville forum (Figure 9).

I was really pleasantly surprised that

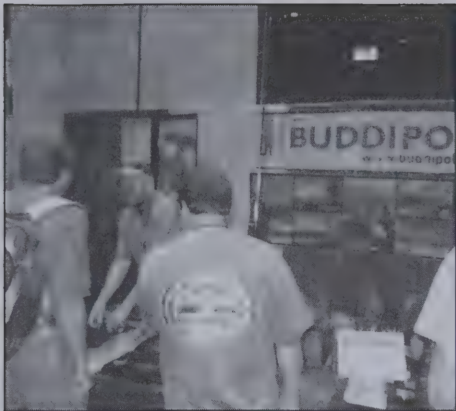


Figure 7—W6HPF's Buddipole booth at ARRL CC.

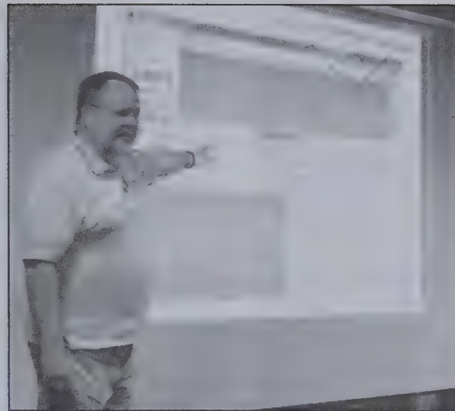


Figure 8—KB5EZ shows how to do all mode field ops.

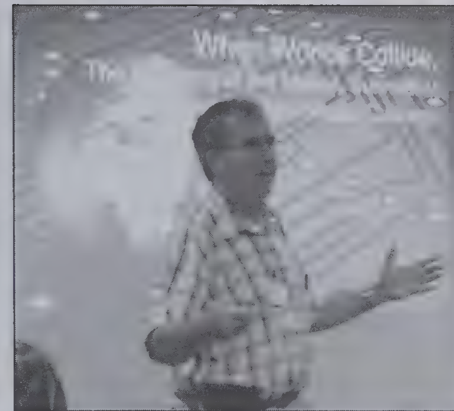


Figure 9—NM4T explores the future of amateur radio.

we had around 65 attendees at this last forum, late on a Sunday afternoon. (One of my Huntsville Hamfest manager friends said he didn't think there was that many people still at the Hamfest hall at that time—said we QRPers must have had them all.) And, if that wasn't enough, it was such a blessing to have the high degree of attention and participation we enjoyed that hour. Thanks so much, Gang!

(A request: I'd really like to hear from you if there are some other topics that you would like us to include in next year's forums.)

Now, Switching to the special TDiH Monte Sano activities. We had just shy of 50 folks participating in this 4-ring circus: Ted's BBQ, John's and Glen's Rebelthon, Chris' and Steve's High-Def Extreme QRP Sport Videos and a number of competing/DX-chasing QRP stations. Figure 10 shows some of the attendees in clusters scattered around the cabin. There were as many at the side of the cabin. We served the BBQ just in the nick of time, before the hamfest weary and hungry mob instigated a palace revolt!

Despite questionable weather forecasts, we had superb evening conditions. (It rained the next day and we had a very wet move-out of the cabin.)

The Rebelthon event was fantastic-thanks Glen and John! Since this is discussed in more detail by the NoGA gang elsewhere in the *QQ*, I won't repeat that here. What I will say is that this is as good as it gets, gang. Figure 11 shows the participants tearing-up their new Rebels (with wild abandon, it appears).

John Henry shared with me (later) that this is the first time he (Figure 12) has ever participated in such an activity, let alone up in a mountain-top rustic cabin. It looks to me as if he's a happy camper!

Don't you just love it when a plan comes together! Figure 13 shows all the modified (and fully functional) Rebels.

While the Rebelthon was in full swing, the majority of us were totally engaged in Chris, W6HPF's and Steve, WGØAT's narration of the high-definition videos we showed outside the cabin. These ranged from Oregon and Colorado mountaintops to Islands in the Caribbean. And, who better to share these extreme-sport (and QRP) activities than these famous guys, right! I can't begin to explain how much fun this was adequately, so let me just say that the cherry that goes on top of this perfect ice cream Sunday was hearing a few of the wives (including mine) say that "Now I understand why those hams are so into these low-power radio adventure activities!"

And the fourth ring of our TDiH circus was all of the portable radio set-ups the gang operated from around the cabins. For example, repeat TDiH participants Jerry-N4EO, Marv, KK4DKT, Gary, WØMNA, Martha WØERI, Jim, AD4J and others operated off and on throughout the TDiH events. Jerry was working big-time DX with 1-watt, running off a mostly discharged battery. Marv (a new Buddipole kit owner) was working SSB and FM. Gary and Martha did a SOTA op from Monte Sano. Jim operated with a custom Hybrid Buddipole multi-band Doublet antenna set-up.

If that wasn't enough mischief, the Rebel owners were competing against each other in a "Worked All 7 Monte Sano Cabins" contest.

Another reason that the Huntsville Hamfest was extra busy this year because it was also one of the six ARRL Centennial Celebration Hamfest locations. We had a


Figure 10—Hungry Mob Awaits BBQ.

Figure 11—The guys tear-up their new Rebels.

Figure 12—John Henry at the Rebelthon.

Figure 13—And all the customized Rebels work.

Figure 14—Huntsville Hamfest W100AW/4 station.

special W100AW/4 station (Figure 14) located just across form the Von Braun Civic Center. A special thanks goes to US Towers for loaning us their 56' Full-Military Trailer Tower system. (Does your tower set-up have full pneumatics, bullet-proof tires and a 7 kW generator?) Those that chose to operate as part of this activity accumulated 3,078 contacts, each worth 5 points).

In closing, there are just too many stories to share in this small column. Stories by and about all who engage in these special QRP activities. Spending time together with others who also love adventure, friendly competition, technology, mentoring and the all that QRP entails certainly adds a lot of fun to our lives.

I want to thank all who participated this time around. I especially want to thank to Chris (Buddipole), Steve (the SOTA man with the goats), John Henry (TEN-TEC staff designer), Glen (the Arduino-meister) and my close friends who help us make these adventures happen each year.

So what might next year look like? Besides our 7 all new QRP forums by really cool people… Rumors have it that there might be a very special Buildathon at the Von Braun Civic Center next time.

As usual, I'm brain-dead at the moment, totally clueless as to what might pop-up on top of Monte Sano in August of 2015. But, those who participate in these TDiH events are already placing their bets that some significant mischief will occur then, fer sure!

So, those who weren't able to join us for the Huntsville experience this time should start planning for next years TDiH trek, (especially if you want to stay in one of the rustic cabins).

Finally, my Quarterly Challenge this time is for you to build-up and/or modify your portable antenna tuners for quick-up, multi-band antennas. Just how efficient can you get these to work? I plan to do this and to use them in a number of Fall QRP adventures. So, please get busy and let me know how it goes!

—Craig, NM4T
'The Huntsville QRP Guy'

QRP means:
"Getting More Done With Less"

CW Sender Part III: CW by Keyboard

Ben Kuo—KK6FUT kk6fut@verizon.net
Pete Juliano—N6QW radioguy90@hotmail.com

First we would like to thank the *QQ* readers who have been following our Arduino project. We only hope you are having as much fun as we are in working with this marvelous tool. There is so much that can be done with the Arduino that we always struggle with what should be presented and in what order so that there is a logical sequence to the articles. We are constantly asking ourselves if we were reading this what would we like to see and so hopefully we are on the right path. Drop us an email and share with us your input.

The third part of this series begins to really showcase the Arduino. LED ON LED OFF is only fun for about a nanosecond; but this segment will show you how to send CW using your computer keyboard while displaying what is sent on your computer screen. As a bonus, using certain designated keys on the keyboard, you will be able to automatically send your call sign and even send the usual "CQ" string. Add in the CW sidetone and keying function of Part II and you have a complete keyboard CW machine. This, of course, is far more useful than LOLO.

Regrettably there is only so much that can be put into an article and so once again we will present concepts and information to fit the "printed version" but will rely on using the http://www.jessystems.com/arduino_build.html website for additional information and detail. As usual, we will endeavor to explain why certain things must be done and try to avoid the pull this, push that approach which frequently leaves out the why. On the website, you will also find detail of the connections to the breakout board for the LCD display and its attendant I^2C backpack used to reduce the required connections between the display and Arduino. In addition, there is a tutorial of the requirements needed to set up the LCD display.

We would like to start first with Figure 1, which is a pseudo software road map of what Part III does in terms of the Arduino "sketch".

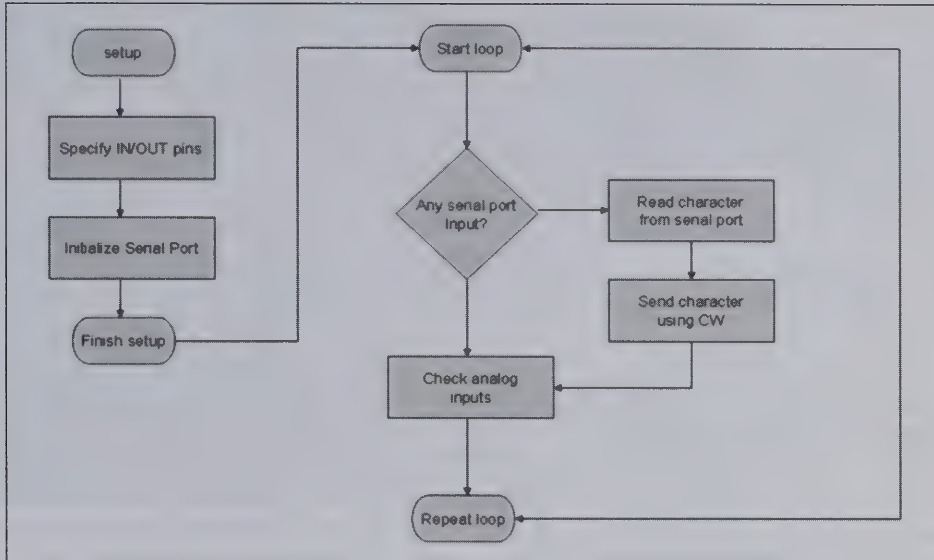


Figure 1—Software map.

- As usual we need to define the constants and variables (we have both)
- Next is the Setup which designates the In /Out pins and of course telling the Arduino to "open" the Serial Port
- That is followed by the Loop which details the logic of what the Arduino must do in terms of checking the input pins and serial port for any change in input and what inputs are being made. This is followed by any response to the inputs such as sounds being generated, data to be displayed on the computer screen or relays to be closed.
- Then we have looping through the sketch to perform this process over and over.

Thus, each section of Part III will (should) reflect the travel down the roadmap. So, let the fun begin.

The Code Mill Meets the Arduino

In the November 1974 issue of *Ham Radio* magazine, W6CAB described "The Code Mill", a project which used digital logic, shift registers, FIFO logic, flip flops, a complex set of clocks, and wiring of a complex matrix of wires to an electronic keyboard, in order to help the ham radio operator send "perfect Morse Code". The project was the pinnacle of digital logic technology of the day. Enter our trusty friend, the Arduino. We'll demonstrate in this project a reasonable facsimile of what the Code Mill provided, all embedded through the hardware we've already built, and a little bit of software magic to translate your PC's keyboard (via the serial port) into a modern day Code Mill.

Expanding On Functions

In Part II, we got a start on using function calls to send our dashes using the function *sendash()*, and sending dots using the function *senddot()*. As we explained previously, the advantage of a function is that you can call that function to do the same thing, multiple times, without having to re-write the software code, or worry about cut and paste errors.

In our next step, what we are going to do is expand beyond dot and dash, to be able to send any character in the alphabet. We're going to do this by using what is called an *if/then statement*. An if/then statement is a commonly used set of instructions in code, which allow you to "test" for certain conditions, and then execute code depending on if a condition is met. For example, we can check to see if we want to send a specific character, and send out the appropriate number of dashes and dots to match that character. That's exactly what we're going to do next.

The function we are going to build,

```
if (letter == 'A') {
  senddot();
  senddash();
}
```

Figure 2—If/Then Statement for the letter A.

```
else if (letter == 'B') {
  senddash(); // B
  senddot();
  senddot();
  senddot();
}
```

Figure 3—If/Then Statement for the letter B.

```
void setup()
{
  pinMode(LED, OUTPUT);  // sets the digital pin as output
  Serial.begin(9600);     // opens serial port, sets data rate to 9600 bps

}
```

Figure 4—Serial port setup.

sendchar(), takes any letter (A..Z, 0...9) and converts that into the appropriate dashes or dots. It does that by comparing the letter sent to the function as a variable (letter), and comparing that to individual characters. For each character, it converts the letter 'A' (upper case only) to a dot and a dash (dit-dah) — using our already written functions from Part II.

For the letter B, we do something similar, except this time we let the software know, by using the *else* keyword, to make the comparison only if it did not already send an A.

We then repeat this for every character and number we plan to send, plus slash and period. The enthusiastic reader can fill in the rest of the letters, or, see the web site for the complete code.

```
// read the incoming byte:
incomingByte = Serial.read();
```

Figure 5—Reading a byte of information from the Serial port.

The Serial Port, Again

At this point, we're going to divert over to handling the serial port on the Arduino, because we're going to put the serial port together with our newly written routine to send a character. Ultimately, this will allow you to type a letter on your serial port from your PC, and have that sent out in CW automatically.

Readers of this series will recall in Part II we added the use of the Serial Port for debugging our last project. We're extending that support this time, to not only output information to the Serial Port, but also to take input from the Serial Port and translating that into CW. Again, in order to support the use of the serial port, we need to initialize the serial port software.

Next, we need to learn how to pull input from the serial port. Once our serial port is set up, this is simply done by calling the function *Serial.read()*, and storing the byte that is read from the serial port in a variable. We call that variable *incomingByte*, but it could be called pretty much anything you would like to. Every call to *Serial.read()* reads the next available character from the Arduino's serial port.

In addition, we use *Serial.available()*, another function, to check if there is a character available—or not. Using an if/then statement again, we use *Serial.available* to check for any waiting characters on the Serial port before reading the character and acting accordingly.

VERY IMPORTANT: When using a PC's serial port, both lowercase and uppercase characters are sent to the Arduino. Traditionally, CW is written in uppercase letters (there is no distinction between upper case and lower case in CW), so we've implemented our routine to look only at upper case. However, that means we need to ensure that all characters sent via the serial port to the Arduino are in uppercase.

To ensure we are looking only at upper case letters, we use the function *toupper()*. In effect, this function takes whatever is sent via the serial port and changes what it sees to an upper case letter, if a change is necessary. (Design note: another alternative is to include both upper and lower case letters in the if/then loop, or force uppercase within the function itself. We'll leave those design exercises to the more software inclined.)

Finally, we call our *sendchar()* function we wrote above, and for good measure also print out the character we received from the keyboard.

```
int incomingByte = 0;   // for incoming serial data

void loop() {

  // send data only when you receive data:
  if (Serial.available() > 0) {
    // read the incoming byte:
    incomingByte = Serial.read();
    incomingByte = toupper(incomingByte); // make sure this is uppercase
    // reflect what was typed
    Serial.print(incomingByte);
    sendchar(incomingByte);
  }
}
```

Figure 6—Sending serial data.

Putting It All Together: The CW Serial Sender

At this point, we now have the two ingredients we need to create a new, Arduino-powered piece of hardware: The CW Serial Sender. We take the two pieces of code we wrote above: the code to send a single letter, and the code to take serial port input. We put them together, and we now have the ability to type any letter, send it to the Arduino via the serial port, and have that letter sent via CW with an attendant

sidetone. With the reed relay we added in our Part II project, the CW character keys our favorite QRP rig!

Adding Speed Control Back In

Finally, although the CW Serial Sender is fully usable after our code above, for true operation you'll want to be able to easily control the speed of sending CW. Although we could do this by using some additional keyboard commands (function keys, arrow keys, etc.), we've preserved the speed controls we created for Part II, and included code to use these for control of the speed using the keyboard, as well.

The connections are identical to Part II, and the only change is how the software uses those connections to change the speed. The code changes (directly from Part II) are shown below.

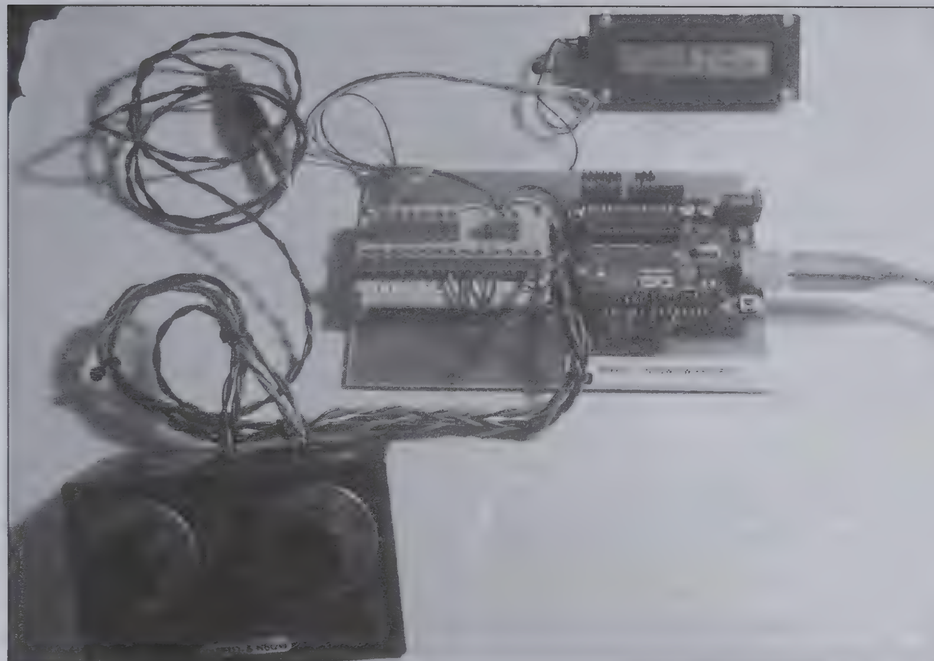


Figure 7—Photo of Part III hardware.

Bonus: LCD Display

Finally, as a bonus to the CW Serial Sender—and as a hardware teaser to future projects, we've also provided a variant of this code which includes simple LCD output to a 16x2 LCD display. In the future, we may extend the CW Serial Sender to work entirely independent of the need for a PC with a serial port connection, so that you can take this out to the field without having to lug a laptop with you.

To add support for the LCD display, we again need to dip into the libraries which are available for the Arduino to support additional functions. In this case, we've tapped into the library *LiquidCrystal_I2C* which allows you to add support for an LCD using the four wire, I^{2}C interface. WARNING: LCD libraries on Arduino are very, very, very nonstandard, and there are at least half a dozen variants on libraries to work with different hardware. For now, we're using one of the more common variants, but due to the complexity have not handled all the different ways this might be implemented. We may cover this in future articles.

A Quick Look at I^{2}C and Arduino

The I^{2}C capability of the Arduino is utilized so that only 4 wires are need to operate the display (Data, Clock, +5V, Gnd). But, this means we need one of the various I^{2}C backpacks attached to our display. These backpacks are essentially small interface boards that take the serial data and clock info from the Arduino and convert that data to the parallel data lines typically used with the common LCD displays. These backpacks have a four pin connector on one end and along the side there are 16 pins that solder into the LCD display, hence the name backpack. I^{2}C address information must be included in the sketch. This where it becomes dicey to have the correct address—otherwise, no display. The builder will also have to have a LiquidCrystal library. The various I^{2}C convertor backpacks use different libraries

```
void loop() {

  // send data only when you receive data:
  if (Serial.available() > 0) {
    // read the incoming byte:
    incomingByte = Serial.read();
    incomingByte = toupper(incomingByte); // make sure this is uppercase
    // reflect what was typed
    Serial.print(incomingByte);
    sendchar(incomingByte);
  }

  //check analog inputs and adjust speed - directly from CW Sender Part IIf
  int dotval = analogRead(analogPin1);    // read the input pin for dot length
  dotdelay = ((dotval * 250L) / 1024) + 30;  // scale our input to be between 30 and 280 milliseconds of delay

  int delayval = analogRead(analogPin2);    // read the input pin for delay between dots/dashes
  dddelay = ((delayval * 250L) / 1024) + 30;  // scale our input to be between 30 and 280 milliseconds of delay

}
```

Figure 8—Analog inputs.

```
void setup()
{
  pinMode(LED, OUTPUT);  // sets the digital pin as output
  pinMode(relay, OUTPUT); //sets the relay pin
  pinMode(tonepin, OUTPUT);  //Sets the speaker output
  Serial.begin(19200);     // opens serial port, sets data rate to 19200 bps. 9600 (slower) can be used.
                          // But you must use the same data rate in the serial terminal program

  lcd.init(); // initialize LCD
  lcd.backlight();
  lcd.setCursor(0,0); // This places a display on the LCD at turn on at the 1st line
  lcd.print("  KK6FUT & N6QW  "); //Any LCD message can be place here. Just make sure there are 16 spaces between the "" marks

}
```

Figure 9—LCD setup.

```
// read the incoming byte:
incomingByte = Serial.read();
if (check_canned_message(incomingByte)) {
   // if =1, we sent canned message, so don't send that character
} else {
    incomingByte = toupper(incomingByte); // make sure this is uppercase
    sendchar(incomingByte);
    Serial.write(incomingByte);
    lcd.setCursor(curcol,1);
    lcd.print(char(incomingByte)));
    curcol = ( curcol + 1 ) % 16; // next column, wrap at 16th character

 }
```

Figure 10—LCD "print" functions.

with some using *LiquidCrystal.h* and others *LiquidCrystal_I2C.h*.

Once the LCD has been set up—in our aptly named *setup()* routine, because it only needs to be done once—we add a few lines to set the position on the LCD (col, row) and print out the character. For simplicity sake, we're just wrapping around the display in this example—for a full implementation you'd most likely create a far more sophisticated routine to handle scrolling of text. For learning purposes, we've only implemented a simple routine here for readers.

Note that the last line of Figure 10 contains a percent symbol. The Arduino uses this symbol for the *modula* function. That means the Arduino takes the value of the (curcol +1) variable, divides the value by 16 and uses the remainder from the division as the (curcol +1) variable. In effect, this causes the value of the variable to return to zero every sixteen characters, the maximum length of a row in our display.

Possibilities, Practicalities, Probabilities

Part III enables the builder to take what has been built in Parts I and II, build on that hardware and turn the Arduino into a keyboard keyer that will connect to your favorite QRP transmitter or transceiver. To keep things simple some advanced features as well as limitations are inherent in Part III. So here is a listing of what can and cant be done.

- The Arduino /Serial Port has a buffer memory so type away, take your hands off of the keyboard and perfect CW is sent until the buffer is empty. So that is a bonus
- The computer must be "on", and your favorite terminal program, such as puTTY, must be "active" on the desktop. Otherwise, the Arduino will not receive any keyboard commands and the sidetone or keying relay will not be engaged. The computer display will follow what you key in plain text with the exception of one canned message where only the equivalent of the key (= key) will be displayed. In Part IV, the complete canned message will be displayed. Bottom line, the Part III sender IS tied to a computer—even with the LCD display—and so is not some small box (at this point) that can be lugged out to a field. Patience please.
- There is much interest in having an LCD display of what is being sent. That capability is included but that poses some issues on standardization much like we strongly suggested using the Uno R3. There are many displays available and so we have limited this version to a 16x2 using only one of the two lines available. Actually a 16x1 backlit display would be ideal. For Part III the computer screen is much better as more data can be displayed and since you are tied to a computer the LCD display has no advantage. The one plus side is that it does introduce the prospective builder to the LCD.
- Sending is limited to the keyboard. We've avoided the complex software additions to support the bug from Part II, in order to make this more clear for readers. That code needs to include collision avoidance algorithms such as if the bug and keyboard key were pressed simultaneously, or to allow a reader to set the mode of operation.

Summary

In this article, we have built upon all we learned in CW Sender Part I and II, and have created a piece of code to be able to send CW using your serial port connection. We encourage our readers to do the step by step work to understand the software sketch. Subsequent articles in this series build on what is being presented in Part III. Don't skip this very critical step. There is a short youtube video on our website that will demonstrate the Part III project.

Stay tuned!

—73 de KK6FUT and N6QW

QRP Clubhouse

Timothy Stabler—WB9NLZ
editor@qrparci.org

Well, I hope that everyone had a good summer. Myself, I did not do too badly. I did spend some extra time as a volunteer at the Museum Science and Industry and wound up taking less time with my radio. That will be changing as I am finally getting the furniture that is going to my daughter out of my garage, which will allow me to find stuff that the movers buried when they moved me in. You know, my Mosley dipole, wire, etc. Yes, I have looked but did not want to take everything out of the garage and then put back in. Meanwhile, I did ask qrp-l for club news, but hardly got anything.

Northern Georgia QRP Club

Michael O'Bannon, KD4SGN, sent this in for the Northern Georgia QRP Club.

Members of the North Georgia QRP Club (NoGA) have been on the move in recent months.

This summer, business and pleasure took Phil, W3HZZ, to Norway, Sweden and France. He carried along his 20/40 meter MTR rig with an end-fed dipole and logged more the 50 QSOs whenever he could get the chance to sit under a tree and put an antenna up in the air.

The highlight of the trip—radio wise—started with operator error. One day he failed to pack a crucial BNC jumper after field ops in the countryside of Provence, southern France. Without the jumper, his "ham vacation" would be QRT for the rest of the trip. He did a quick search of QRZ.COM. Though there were no hams in nearby towns, Giles, F6EPE, was in Avignon, about 20 miles away. Giles responded to Phil's email—no problem, he had a jumper and he'd be back in a few days from a hamfest in Germany. Phil made a detour to Avignon one evening and was greeted not only by Giles, but by fellow members of the radio club of the French Electric Company, ECF. They took him to their shack where they were in the middle of a contest. The scene was not unlike Field Day in the USA; two hams were operating and four hams were eating. But instead of hot dogs and cokes, the French hams were seated at a table with bread and cheese.

Seven NoGA members have each acquired a TEN-TEC Rebel 506, a two-band open-source transceiver, and are beginning to explore the rig's capabilities. These "Georgia Rebels" include Tom, AK4NY, Clark, WU4B, Lee, AA4GA, Phil, W3HZZ, Mike, KD4SGN, Newt, N4EWT, and Phil, K4PQC. In August, several of the Georgia Rebels trekked to the Huntsville (Alabama) Hamfest to pursue their interest in this little rig.

In addition to being a great general ham convention, the Huntsville Hamfest includes a number of QRP-oriented activities every year. This year, the QRP Multi-Forum included talks on Arduinos, the Rebel 506 and beyond, portable antenna systems, measuring RF loss, working the modes with QRP, the Maker culture, and bicycle mobile. NoGA member Jim, W4QO, kicked off the forum with a talk on "Why QRP?", and NoGA member, Jim, AD4J, presented on hybrid antenna designs. A Saturday gathering at nearby Monte Sano State Park has become an annual tradition for Bar-B-Q and QRP. For Rebel owners, the first "Huntsville Rebelthon" was held, including discussions with John, KI4JPL, from TEN-TEC. After a build session featuring the new Universal Shield from the Huntsville QRP SkunkWerx team, a number of Georgia Rebel rigs now have new band switching and display capabilities.

Club members pursued other interests at the Huntsville Hamfest, as well. Summits on the Air enthusiasts got a chance to meet, plan and view a video of N7UN reaching several summits in the West. Buddipole enthusiasts met the company owner and saw video documentation of the Buddies of the Caribbean expedition to St. Lucia. The informal center of QRP activities for the hamfest, Monte Sano State Park, is a one point summit in the SOTA, and Dick, K2UFT, made SOTA QSOs with several Russian stations on 20 and 30 meters using his MTR radio at 4 watts into a random long wire. Dick reports that the park provides Spartan accommodations but plenty of trees for hanging antennas.

Back in Georgia, Lee, AA4GA, has continued explorations of the Rebel and documented many of his findings on his website. He has experimented with band switching mods, audio and bandwidth configurations, and display alternatives with the careful eye and ear of a devoted QRP operator. Lee's observations provide an in-depth view of the rig and potential modifications. He has designed a new layout for small displays that sounds like a great fit for many operating situations. TEN-TEC Rebel owners will find his insights valuable as they customize their rigs to their own needs. Take a look at Lee's website at http://www.aa4ga.com/.

The CW Open, sponsored annually by CW Ops Club, was held on September 5-6. Dick, K2UFT, joined a 10 member QRP team (Team Thunder) organized by Dean, NW2K, all running 5 watts or less. The contest was divided into 4 hour segments, Friday evening, Saturday morning and Saturday early evening to maximize propagation possibilities in various parts of the world. Dick used a FT1000MP cranked down to 5 watts output. It was pretty hard to "run" stations by calling CQ with his dipoles, so most contacts were "search and pounce." He was able to attract European contacts on 40 meters Friday evening and 20 meters Saturday morning, finishing with 210 QSOs. According to Dick, "There were many good operators in the contest. Very few contacts were 'hard,' even very few repeats were required. Surprising to me was a fair number of contacts on 80 meter CW despite the high QRN level and 5 watts of power!"

In July, we mourned the loss of a long term club member, Russ, AE4NY, who became a silent key. He was a high speed code operator in the U. S. Army Air Force during World War II, serving in England, North Africa, Sicily and Italy from 1941 to 1945. As a radio amateur, he was an enthusiastic and tireless supporter of QRP and NoGA. Russ was a club member for 14 years, an organizer of many club events, and was always supportive and encouraging with newcomers and new ideas. A decade ago, Russ set a goal to make one QRP QSO each day of the year, and for many years he met that goal. On February 11, 2011, the club declared Russ Richardson Day, and Russ became a mem-

3-band regenerative receiver done by Gary Auchard, WØMNA. This won the Best of Show Award at Ozarkcon, 2014. By error, it was not identified correctly in the Ozarkcon write-up lasat issue.

ber of the QRP Radio Club International "Honor Roll." Club members and the QRP world will miss him.

The North Georgia QRP Club is a group of hams who enjoy building and operating low-powered radio equipment. We welcome others who share these interests to our meetings on the second Saturday of each month in Atlanta, Georgia.

Eastern PA QRP Club

I had a note from Ron Polityka, WB3AAL, that this club had folded, for whatever reason. I was sorry to hear this. Ron used to come to Alanticon and talk of the club's activities on the Appalachian Trail. He told me he used to do that, at least once a month but knee problems basically forced him to stop. I have two totally replaced knees, so I am familiar with those problems.

So he started to make at least one CW contact a day and, minus two sick days last year, did very well. All I can say is keep going, Ron.

Boschveldt QRP Club

About the same day as I got the message from Ron, Ed Breneiser, WA3WSJ, sent me this (Ed was a member of the Eastern PA QRP Club):

I thought I would let you know that there's a new QRP club in town.

It's the Boschveldt QRP Club. We have around thirty-three members to date. The word Boschveldt is a very ancient word. If fact, it's no longer in any modern dictionary. The word Boschveldt has a few meanings such as wilderness, flat plain with brush etc. The mission of the club is to promote portable outdoor QRP activity in the wilderness, forest, parks etc.

The club has a website and we started an award program. We also have a club call —W3BQC.

As you might imagine, we are a small club due to the nature of our mission. We like to hike with our QRP rigs in the wilderness. While this sets us apart from most radio clubs. it also severely limits the membership. I don't foresee the club growing into a large club. But, we do have FUN!

If anyone hikes or operates portable QRP in the woods etc. and would like to join our club, please send WA3WSJ an email. First, go to our website and look around to get a feel for the club.

https://boschveldtqrpclub.shutterfly.com/

Four State QRP Group (4SQRP)

4SQRP volunteers took a short time for a deep breath after record-setting attendance at our 2014 OzarkCon QRP conference. We received many compliments on this year's conference so it made all the hard work worth it. 4SQRP staff wishes to thank all those who supported this year's efforts.

But the rest was short-lived. New kits needed to be developed in order to raise the funds necessary for the 2015 rendition

Call	Name	Total	Call	Name	Total
KV6Z	Bill	59	WNØWWY	Dale	7
WAØITP	Terry	48	WBØQQT	Steve	6
W2SH	Charles	27	WD9F	Woody	6
KF7WNS	Gary	25	KB4QQJ	Randy	4
ACØBQ	Johnny	23	KB5FCF	Joel	4
WØOTM	Marshall	18	NØNBD	Paul	3
AA5CO	Bruce	17	NBØW	Scott	3
WØCLR	Jerry	15	WA4ZOF	Tom	3
WB6HVH	John	13	K4EQ	Dale	3
NV9X	Jim	12	WØXI	Phil	2
K7QO	Chuck	10	KU4GW	Cliff	2
KC9UNL	Curt	9	AAØVE	John	1
WØCH	Dave	9			

4SQRP's Sunday Sprint standings.

of OzarkCon. At this writing, parts are arriving from around the globe for the new Ozark Patrol, introduced at this past OzarkCon, and will soon be put into bags and made available for sale. The Ozark Patrol is a simple two-band Regen Receiver designed for 4SQRP by David Cripe, NMØS. Also in the wings are two new kits, an updated version of our popular EZKeyer, complete with expanded memory and more bells and whistles; and the new Menthodyne, designed for 4SQRP by David Cripe, NMØS. The Menthodyne is a direct conversion CW transceiver that will be available in four different versions: 60, 40, 30, and 20 meters.

In other club activities, by press time, the winner of the annual Sunday Sprint series will have been decided. At this time, Bill, KV6Z, has impressive lead but Terry, WAØITP, is within striking distance should propagation favor him. Final results can be found on the 4SQRP website at www.4sqrp.com .

Also, by press time our Annual Brutus Bash will have been held on September 13th and 14th. As we write, members are packing up their portables, antennas, tents, camping equipment and kites for another great weekend in Eastern Kansas. Big Brutus is the largest (16 stories) surviving electric shovel, located near West Mineral, Kansas, just south of Pittsburg. Everyone is looking forward to a fun weekend and appears we will have another record turnout this year.

Finally, just a reminder for our club's on-air operating activities. The 4x4 Sprint is An Outdoor Operating Event on the 1st Saturday in October from 1700 to 2100 UTC. Our weekly nets are:

Wednesdays:

7:30 Central time ... 40M CW Net on 7122, WQ5RP/ACØBQ NCS

8:00 Central time ... 80M CW Net on 3564, WQ5RP/WAØITP NCS.

8:30 Central time ... 40M CW Net on 7122, WQ5RP/ACØBQ

9:00 Central time ... 80M PSK Net on 3580.5, WQ5RP/NØTGR NCS

All are welcome! After the nets, a list of check-ins will be posted on the Four State reflector.

We also have a Thursday net at 8:00 AM Central on 7122—this is a 4SQRP members-only net.

All are welcome! After the nets, a list of check-ins will be posted on the Four State reflector.

That seems like all the club info I had sent to me. Just remember, I have an open invitation to all clubs to send me club info. For the Winter issue, I need your material into me by December 10th.

—72, Tim, WB9NLZ

Kazimierz "Kai" Siwiak—KE4PT ke4pt@amsat.org

The Gap Resonated HF Loop

The small gap resonated HF loop is popular for portable QRP operations. In the previous Ionospherica we explored the bent dipole near the ground, and how its fields couple to the ground and to the ionosphere. This time we'll take on the small loop near the ground. The loop is often thought to be a purely magnetic antenna, but it can have a very strong electric near field as well as a strong magnetic field. We confine our discussion to small loops, those less than one-tenth of a wavelength in diameter, and resonated by a capacitor in the loop gap.

We will look at the near fields of the loop, how it couples to the ground compared to a dipole, and how it couples to the ionosphere.

Figure 1 shows a portable ham radio operator using a small loop. HF loops, are typically about 1 m in diameter, incorporate a tuning-resonating capacitor and some sort of feeding mechanism, which can take the form of a secondary feeding loop or a shunt feeding arrangement. The loop and capacitor form a high-Q resonant circuit where the "beneficial" loss is radiation resistance. Measuring the Q and performance of a small HF loop are discussed in [1].

Loop near field analysis is very complex. Necessarily, this will involve some equations, but we'll keep them to a minimum and as uncomplicated as possible! We'll look at some specific results, including close electric near field expressions that are not readily available elsewhere.

Figure 1—The small gap resonated loop fed by a secondary loop makes a compact portable HF antenna for QRP expeditions. ***Source: ©2014 Chris Dean, KD7CNJ, used with permission.***

The Close Near Fields of Small Loops

According to derivations in [2], the loop current I(ϕ) around the cirumference ϕ of the electrically small loop is not constant, but has a ϕ dependency,

$$I(\phi) = I_0\left(1 - 2(kb)^2\cos(\phi)\right) \quad (1)$$

where I_0 is the loop feed current, b is the loop radius, and $k = 2\pi/\lambda$. Everywhere on the loop of wire radius a the surface tangential magnetic field is,

$$H_{surface} = \frac{I(\phi)}{2\pi a} \quad (2)$$

The current correction term in Eq (1) that depends on ϕ is the first term of a Fourier series expansion of the exact loop current, and is usually ignored. This term, however, results in a charge accumulation on the loop, and that in turn gives rise to an impressive close-near electric field.

The electric fields near the loop are very complex and very difficult to calculate analytically, however at the center $(x,y) = (0,0)$ of a small loop in the x-y plane (see Figure 2) the result is remarkably simple,

$$E_{0,0} = -j\frac{\eta_0 k I_0}{2} \quad (3)$$

where $\eta_0 = 376.7\ \Omega$. Note that the electric field at the loop center does not depend on any loop dimensions (for an electrically small loop). This electric field is y-directed, or horizontally polarized, inside the loop for a vertical loop oriented with the resonating capacitor at the top as shown in Figure 1. More on this later.

The magnetic field at the loop center, using classic solenoid analysis, is simply

$$H_{0,0} = \frac{I_0}{2b} \quad (4)$$

Unlike the electric field in the center, the magnetic field depends on the loop diameter $2b$. The wave impedance Z_w at the origin is the ratio of $E_{0,0}$ to $H_{0,0}$,

$$Z_w = -j\eta_0 kb \quad (5)$$

Since Z_w in the loop center is not zero, the small gap-resonated loop is clearly not

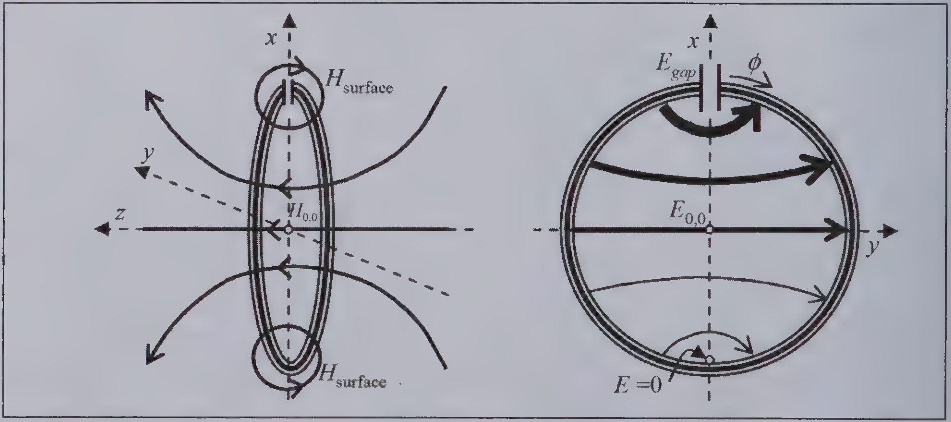


Figure 2—The (left) solenoidal magnetic fields on the loop surface ($H_{surface}$) and in the center ($H_{0,0}$) are easily determined. The (right) electric fields at the center ($E_{0,0}$), the gap (E_{gap}) and opposite the gap ($E = 0$) are also easy to determine.

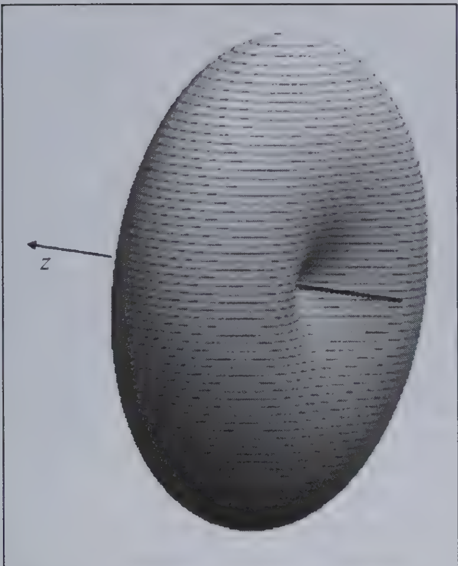


Figure 3—The magnetic far field of a vertical loop is solenoidal. Its electric far field wraps around the z-axis and is vertically polarized near the horizon.

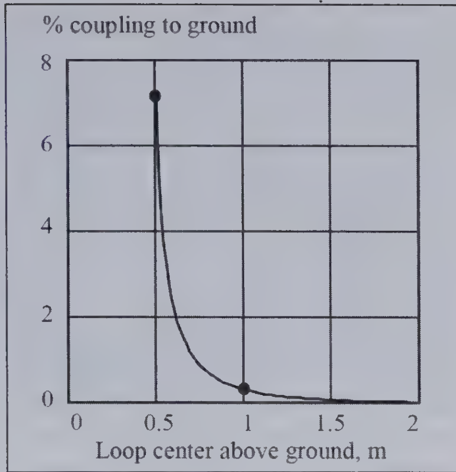


Figure 4—Loop field coupling to the ground vs. height of the loop center in meters.

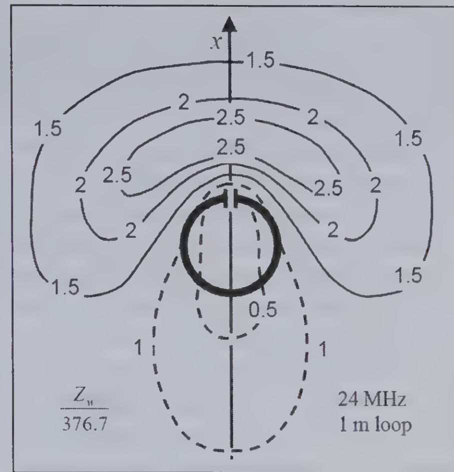


Figure 5—The electric field energy exceeds the magnetic field energy when the field impedance Z_w/376.7 exceeds 1 (solid contours).

a purely magnetic antenna, and in this orientation its close near-field polarization is at right angles to the far field polarization!

In addition to providing insight into the behavior of small loops, equations (1) to (5) are useful for validating the results of numerical electromagnetic code (NEC) computations.

We can easily find the exact electric field at three specific places inside the small loop: $E_{0,0}$ (Eq 3) at the loop center, E_{gap} across the gap-capacitor, and opposite the gap, where $E = 0$. The electric field at the gap-capacitor is easy to find from the rms capacitor voltage,

$$V_{cap} = \sqrt{X_C Q_L P} \qquad (6)$$

where X_C is the capacitor reactance at resonance, Q_L is the loaded Q of the system [1], and P is the power radiated by the loop so,

$$E_{gap} = \frac{V_{gap}}{g} \qquad (7)$$

where g is the gap dimension. V_{gap} can be almost 1 kV peak at QRP power levels.

An important take-away here is that there can be an enormous electric field near the small loop whose origin is the slight departure from a constant loop current seen in Eq (1). That field is of great interest when we assess RF exposure from a small HF loop.

Loop Far Fields

In the orientation of Figure 1, with the plane of the loop perpendicular to the ground, the far magnetic field pattern (see Figure 3) is toroidal. A slice through the *y*-*z* plane (parallel to the ground) has a figure-eight pattern, with nulls directed along the *z*-axis, the same as that of a horizontal dipole oriented along the *z*-axis. The loop electric far field wraps around the *z*-axis and is vertically polarized near the horizon.

Coupling to the Ionosphere and Earth

The loop radiation pattern null on the *z*-axis becomes less prominent and the pattern more omni-directional as the radiation angle relative to the ground increases. This means that loop radiation will couple in all directions into the ionosphere at the 5 to 20 degree elevation angles that are important to DX communications.

Although the electric field inside the loop is horizontally polarized, far from the loop (more than a few wavelengths) the electric field has only a E_ϕ component, so the polarization is vertical at angles near the horizon!

Small loops couple weakly to the ground, as seen in Figure 4. The mutual inductive coupling to ground for the 1 m diameter loop is 7% when resting just above a perfect ground, and only 0.34% when the center is 1 m above ground. This is far less than the coupling to ground of a horizontal dipole at the same height. I based my calculations on Neumann's integral formula for coupling between a loop and its image in a perfect ground. For the QRP operator this means that the loop tuning will not be perturbed very much by changes to the height above ground.

Loop RF Safety

With just 10 W RF power the voltage on the loop at the tuning capacitor peaks out at nearly 1 kV peak, (multiply Eq (6) by 1.41), and is a safety concern. At 10 W the FCC compliance distance for RF exposure, see [3], is between 1.3 and 1.5 m (<5 ft) from the loop center across 7-29 MHz. Figure 5 shows that the electric field near the loop may be of more concern than the magnetic field, especially on the capacitor side (top) of the antenna.

Enjoy QRP operation with your loop - safely!

References

1. A. Findling, K9CHP, and K. Siwiak, KE4PT, "How Efficient is Your QRP Small Loop Antenna?", *QRP Quarterly*, Summer 2012.

2. K. Siwiak and Y. Bahreini, *Radiowave Propagation and Antennas for Personal Communications*, Third Edition, Artech House, Norwood MA: 2007, Chapter 11.

3. E. Hare, W1RFI, *RF Exposure and You,* ARRL, Newington, CT, Table 17, p. 8.77, www.arrl.org/shop/.

Kazimierz (Kai) Siwiak, KE4PT, is an avid DXer who packs a DX-go-bag station on his travels. His technical writings appear in many publications. ●●

Sherlock Investigates Death on the Trail

Paul Signorelli—WØRW w0rw1@msn.com

Sherlock Holmes investigates a PRC319 Mission Failure.

It was a dark and cloudy day when a PRC319 was returned to SAS HQ G4 Stores for analysis from the field. The Sigs Platoon Technician took a look at it but there was not much on the failure ticket.

Once again my Blogger John Watson was unavailable to accompany me, so these writings are only from my sketchy notes. I hope they prove helpful to others faced with such a singular failure.

I took the 'Tube' over to Charing Cross Station and then over to Whitehall to pick up the radio from my brother Mycroft. It was wrapped in a plastic bag and the operator had attached some white mine-tape to the radio stating the following:

"The field operator was on LP (Low Power) CW when the radio first dropped its memory (It zeroized itself). It had lost internal power and then came back on by itself with no frequencies in left memory.

He re-entered the Command Frequency and the unit continued operating, but it tripped off again and dumped the memories again after 30 additional minutes of operation. Then after about 1 hour of operation it dropped out and would not come back on."

It was Dead in the Field.

The Sigs Platoon Technician confirmed the failure and sent it to MOD on a G1098.

I took the radio and caught a cab to Mullard Electronics LTD (MEL) in Crawley, (MEL is now Thales). They have to keep track of sensitive items like this, even though PRC319 was kind of the 'odd man out' when it came to drawing a radio from stores because it was complicated and few operators had training.

The '319 is clandestine radio, it is not marked as 'PRC319' on the outside and none of the PECs (PCBs) have any silk screened reference designators.

Some equipment like this have a small "red cross" on the chassis, to be used as an aiming point for rapid decommissioning. There were never any '319s lost or decommissioned in the field.

After traveling down London Road A23 to Manor Royal, arriving at MEL, the MEL engineers were waiting for me. We took the radio straight away into the MEL Failure Analysis Lab.

The MEL Repair center had all the 3rd level repair equipment and spare parts. This included all of the special unit testers (TS2010) and the subassembly testers for all the '319 modules and thermal chambers for environmental testing. During production the Philips TCXO and TCXO PEC were married together and the frequency was measured over temperature in a thermal chamber. The frequency offsets at each temperature were recorded and placed on to a ROM which then corrected the final TCXO output. This generated a highly stable frequency source over the full Military temperature range (-31C to +55C).

They had a big chalk board in the repair area that showed the all the recent '319 failures and their repair status.

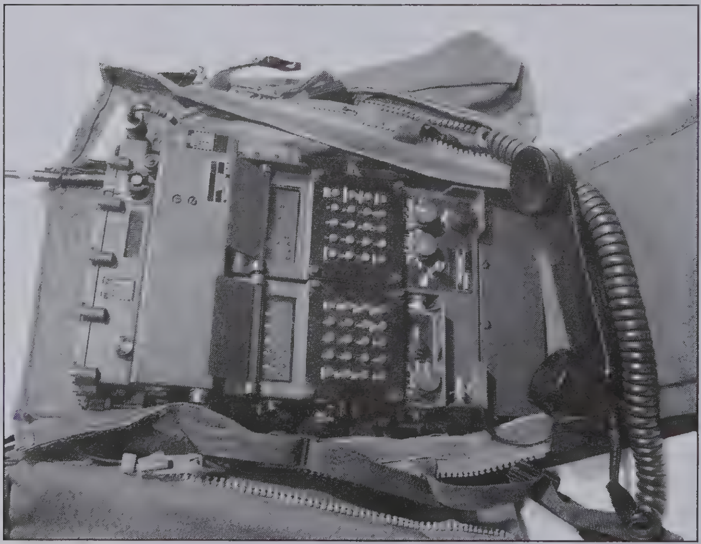
They also use a '319 Fault Analysis Sheet (FN2681 traveler) that records all the defects and repairs. They had the history records pulled so I could review them. The '319 had very rarely failed in the field, short of a few battery connections that were easily corrected. The lab connected the unit to a current limiting power supply and found that it was drawing about 15 mA, so it didn't blow a fuse.

The radio is fully sealed from rain, sand and dust, etc., but the rubber key pad can capture all kinds of debris. I removed the 4 screws on the key pad bezel and carefully brushed out a small pile of dust onto a white paper. There I found sand from Iraq here and a smaller grains of white dust. I placed them under a microscope and saw small hexagonal markings on them, like the calices of weathered coral but recognized it at once as the Bolax Gummifera, called "Balsam Bog" in the Falklands.

It comes only from the slopes of Mt. Harston on Saunders Island.

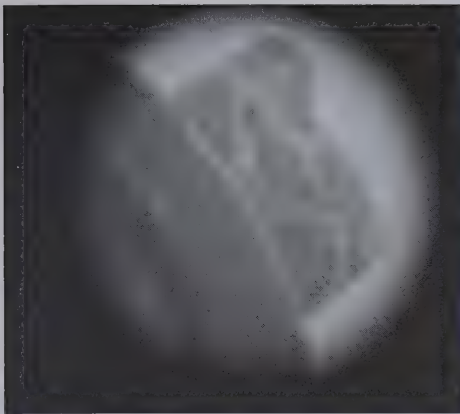
The Falkland 74 day war took place in a very humid and cold environment so the radio probably never failed in the Falklands because it was so cold. There was also fine desert dust, so it was probably placed in service in Iraq where it was exposed to the Haboob.

This defect can be caused by a reversed



The PRC319 radio set.

View of the culprit PCB.



The damaged washer.

A proper shoulder washer.

Ta cap, an open ALC line or the Power Supply. When I opened the radio I swapped the modular power supply with a known good one and the unit began to work correctly. The original power supply had failed. The power supply module is small and fairly simple, there is only one switching FET.

The BUZ20 FET (TR4) had shorted . Secondary damaged was also found, (Secondary damage is damage caused by the primary failure). ML1, and the TR4 source resistors (R17,18 and 19) were also blown open. When i removed TR4 and noticed a slight crushing of the red plastic feed through shoulder washer that is used to mount TR4 to the heatsink (see picture). If the FET is not flush it won't conduct heat to the heatsink.

The FET mounting screw was tight but the FET Tab was not tight against the chassis. That causes the FET to overheat and short out. The designer should have selected a shoulder washer that was about 0.015 inches shorter. This assembly process is blind and the assembler can not see the seating of the FET to the heatsink.

The CW duty cycle, long mission time reported by the field operator and high temperatures probably caused the radio to fail where previous missions in the Falklands were in a colder environment and may have only required a few minutes of SSB operation. That would not have over stressed the FET.

The failure could have been caused by Tantalum capacitor scintillation, but that usually happens right when the radio is turned on. The scintillation usually either self-heals itself or causes it to short right away.

The unit probably randomly dropped out several times because the '319 protection circuits shut down the radio before the FET shorted out and destroyed itself. If this had not been a catastrophic failure the exact cause of the failure might have never been found.

The FET was de-potted using hot M-Pyrol and the die was melted down from the thermal runaway.

All the Ta capacitors were also checked to make sure they were all 'clocked right', (That is their polarity was not reversed).

There was a previous PRC319 that failed after many hours of operation in the field because of a reversed Ta capacitor.

These capacitors have radial leads and are the "Orange Drop" type, the positive anode is identified only by a flat lead which is hard to identify. It was reported in the "Case of the Mixed Orange Pips."

The radio has been returned to SAS inventory on a Form 1033 and should live another long life.

Although we found the root cause of the failure and had a good corrective action, it could not be implemented because the production phase of the program was over. It shows the value of real time failure analysis during production.

—Sherlock (WØRW)

Building and Using an L-Q Meter

Fred Piering—WD9HNU fpiering@yahoo.com

I had the pleasure of again attending the Four Days in May Conference this year. During the excellent presentation of "Many ways to Homebrew" by Harold Smith, KE6TI, during his discussion of winding and mounting toroid coils, an audience member offered that it was critical to leave a 30 degree gap at the bottom of the toroid windings and that it provided the maximum Q of the coil when done so. I thought, "Gee, I didn't know that!" So I thought that I would investigate that phenomena and share it through the *QRP Quarterly* magazine. Then I realized that it would only amount to a paragraph while our editor is always looking for articles. So, I thought, why not address the measurement of coils, the equipment used and in the end, address the Q of the coils, measurement of inductance and self capacitance and the change of inductance with winding spacing as well as the effect of capacitor Q.

To begin, I would like to share my circuit for the measurement of inductance and subsequent Q measurements. This circuit has been used for years with all types of inductors. To make it suitable for measuring Q, I had to make one modification. In the case of Q measuring, the source impedance must be very low while driving the series L and C that are used for the measurement. The schematic of the circuit is shown in Figure 1.

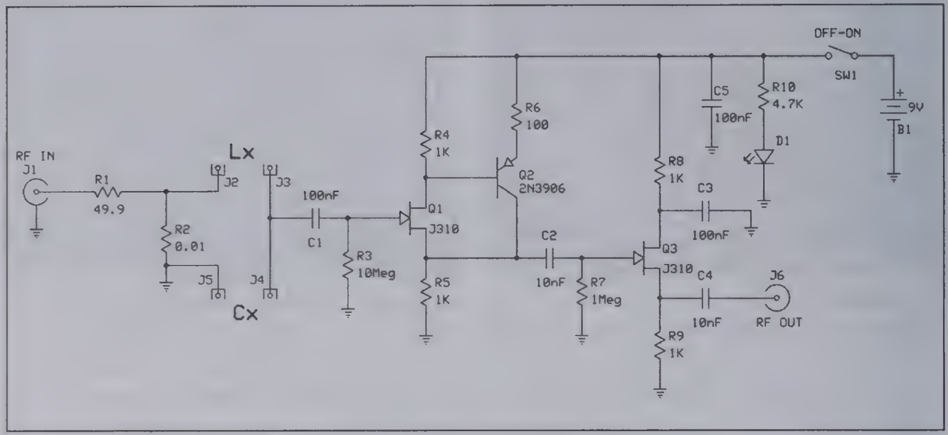


Figure 1—L-Q Meter schematic.

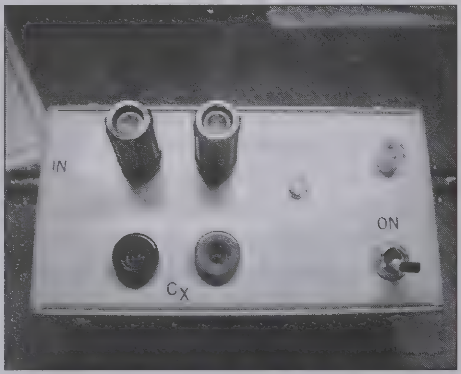


Figure 2—Exterior of the L-Q Meter.

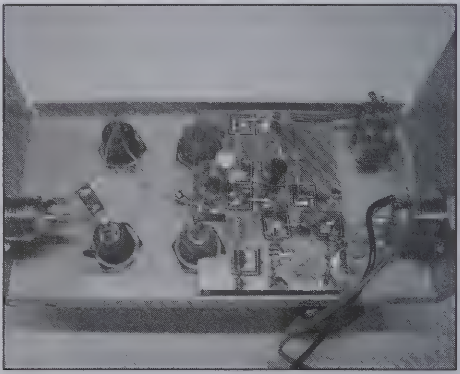


Figure 3—Internal construction.

The **Lx** terminals are Binding posts and the **Cx** terminals are banana jacks. It is best to minimize the series inductance of the capacitor terminals. All other components are standard, off the shelf parts. A Bill of Material and Digikey part number and cost are included at the end of the article. The test signal is supplied by a signal generator, with a nominal input of 35 mV RMS. The circuit presents a 50 ohm load and the resistive tap provides source impedance for the L/C circuit of 10 milliohms. Despite the dramatic step down in signal level, with a Q of approximately 150, some 35 millivolts are available for measurement. I will address that more, later. The unit exterior is shown in Figure 2.

The internal construction is open wiring and uses MeSquares from QRPMe. A view of the internal construction is shown in Figure 3. It is important to keep the wiring short and the parasitic capacitance and inductance low. Therefore, I used a strip of tin for the ground path and stood up the input resistor to the first FET to minimize the gate capacitance which is in parallel with the external capacitance. A close up of the FET gate connection is shown in Figure 4. What is shown is a 2N4416 FET from an earlier version. The 2N4416 is getting harder to find and more costly. So, I have substituted the J310G which is readily available and works just fine. There is one more part that must be fabricated to support the use of the instrument. Later I will detail the specifics of how to make the measurements. One part of that is finding a capacitance that causes resonance at the frequency that you want to make the measurements. This usually requires a fixed capacitor or sometimes several in parallel as well as a variable capacitor to adjust the circuit to resonance at the desired frequency. A circuit is made that has banana plugs to plug into the **Cx** terminals. Also included are two push pins that allow for the addition of fixed capacitors. The circuit has the standard 3/4 inch spacing. This is to allow for the capacitance board to be plugged into a capacitance meter and total capacitance mea-

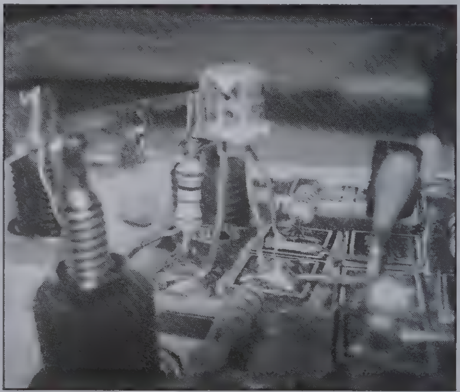


Figure 4—Gate lead attachment to the top of the gate resistor.

Figure 5—Fixed and variable capacitance board.

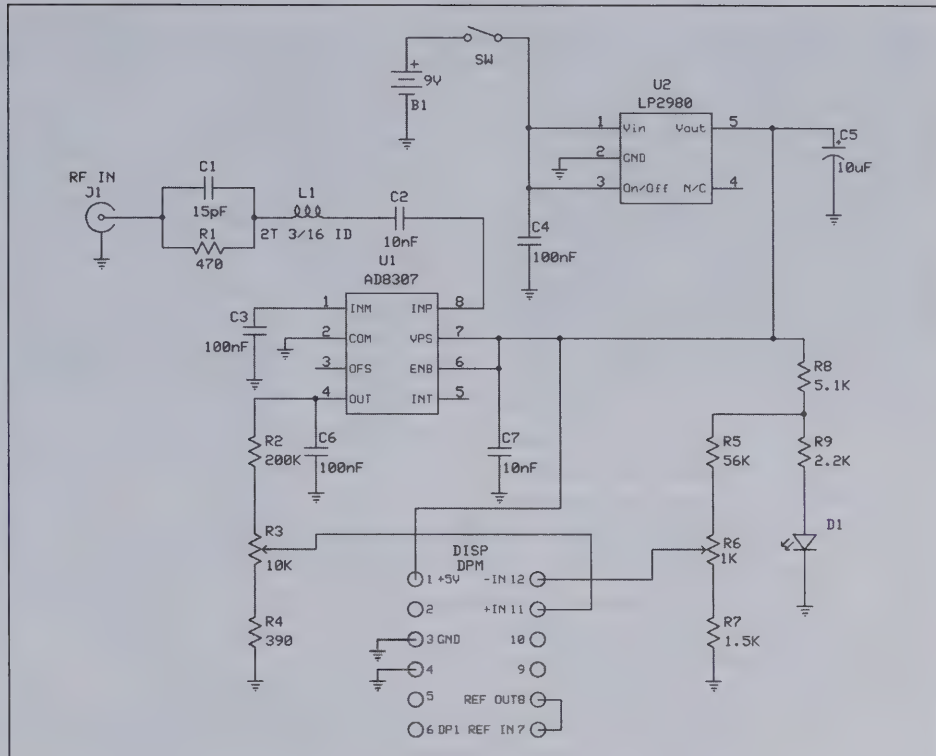


Figure 6—RF RMS voltmeter schematic.

sured. The board is shown in Figure 5. You can see a small black surface mount trimmer on the board as well as a fixed capacitor in the push posts. To make the measurements you need a signal generator and an RF voltmeter.

I have the good fortune to own a Fluke 8020A Digital True RMS meter which is good to 20 MHz or so. In addition, I have a Boonton 92A RF Millivoltmeter which has a mirror analog scale and is good to 1,000 MHz. I suspect many are not as fortunate. Therefore, I constructed a simple and inexpensive (in comparison) RF RMS voltmeter. It can be used with the L-Q Meter described above. The circuit is a very simplified one copied from the design of Steve Whiteside, N2PON as published in the August 2008 *QST*. The simplified meter circuit schematic is shown in Figure 6. I used the SOIC 8 SMD version of the AD8307 as it was readily available as a sample part and also from Digikey. The electronic assembly is shown in Figure 7; the overall assembly is shown in Figure 8. The input, which is shown with a resistor, capacitor in parallel as well as a small inductor, is shown in Figure 9. I used a carbon composition resistor and made the inductor from winding the resistor lead over a small drill shank. For our use in measuring inductance and Q, the most important aspect of this voltmeter is the linearity. However, since I had the equipment, I did calibrate the unit. Here is the simple procedure: Set the RF input to a convenient frequency. I used 10 MHz. Set the RF input to –70 dBm and adjust R6 so that the meter reads –70.0, Then increase the signal to 0 dBm and adjust R3 for a meter reading of 0.00 volts. There will be a small interaction and you will need to do the adjustment several times. A Bill of Material with Digikey part numbers and prices is included at the end of the article. The AD8307 and meter are not cheap. You can substitute any meter that you would like. I used this one because it allows for the power supply ground to be connected to and the same as the signal ground. Many

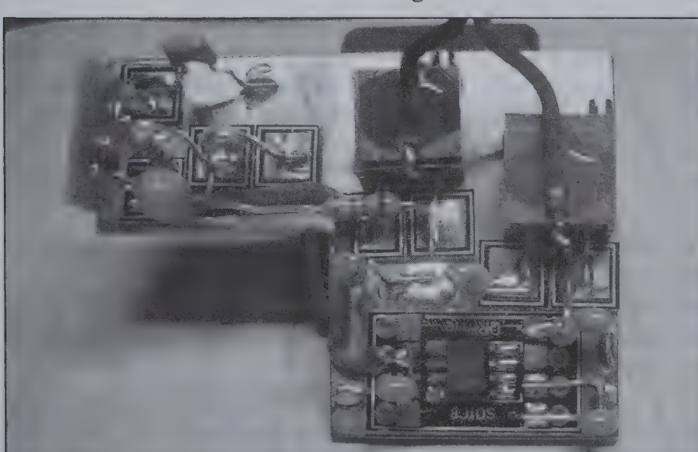


Figure 7—RF RMS voltmeter electronics.

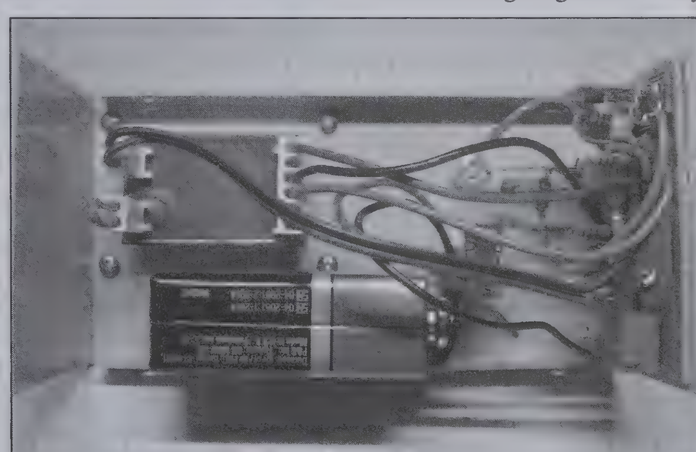


Figure 8—RF RMS voltmeter assembly.

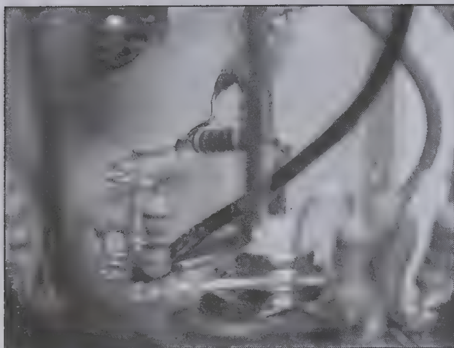


Figure 9—Input circuit.

of the really cheap meters will not let the supply ground and signal ground be the same, requiring you to use a separate 9 volt battery to supply the meter, for me an aggravation! This was not meant to be a detailed construction article and it is expected that with the schematics and pictures, assembly should be easily achieved. So, now on to the measurement section.

Making the Measurements

To start our adventure into the measurement of toroids, we first have to wind one. I didn't want to deal with a bunch of .9999's so I said I wanted 1.1 uH. This would be a good value for testing at 7 MHz and 14 MHz. To get reasonable Q and good temperature characteristics, I chose the Amidon Associates T37-6 core. There are at least two ways to get the required number of turns. If you like math, you can use the formula provided by Amidon:

$$Turns = 100\sqrt{\frac{L(\mu\text{H})}{A_L}}$$

So, if we plug in 1.1 uH for L and 30 for the A_L and do the math we come out with 19 turns. Another way is to go the DL5SWB website www.dl5swb.de and download the program, mini Ring Core Calculator ver. 1.2 and plug in the numbers. The results are shown in Figure 10. It was wound with #26 magnet wire. About 90% of the time I have used this L-Q meter circuit, I have been primarily interested in the inductance of the coil. With toroids and air solenoids there are usually formulas that get you pretty close. Sometimes you have an unknown part from the junk box and want to know its characteristics. If you are doing a VCO with a known variable capacitor, knowing the exact inductance is handy. Also, if you are making a filter, the Q is important and allows you to calculate the insertion loss of the filter. Now that we have our coil, it's time to do some measuring.

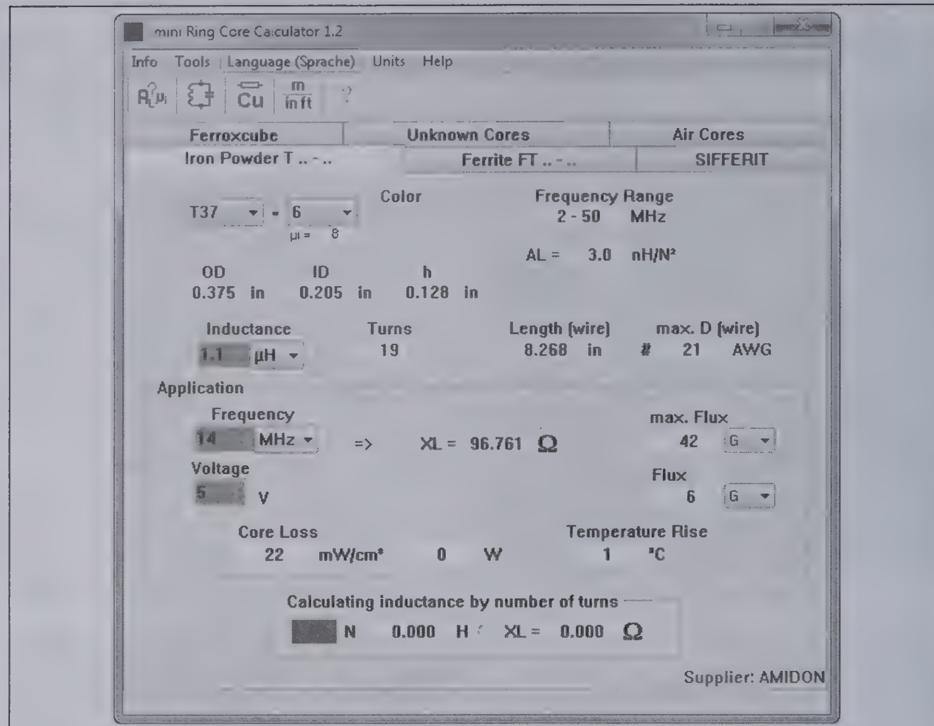


Figure 10 mini Ring Core Calculator from DL5SWB.

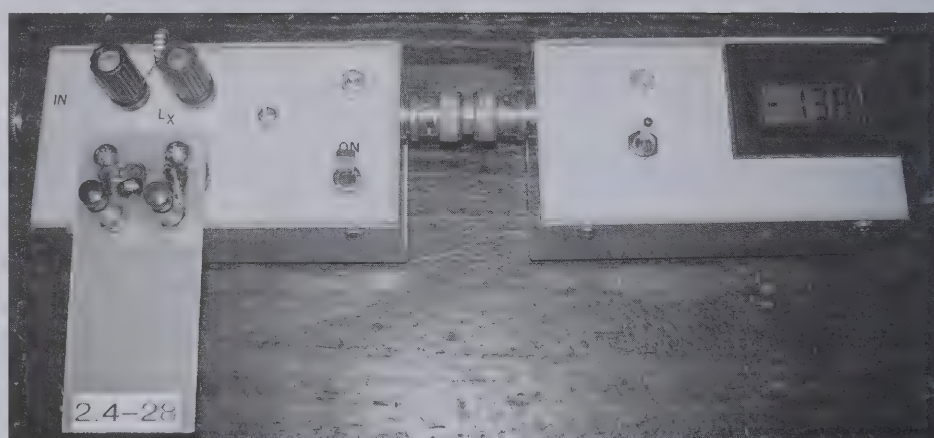


Figure 11—Test setup.

We will be testing three configurations of the same toroid. The first will be with the turns evenly spread over the entire coil diameter. The second test will be with the infamous gap of 30°. The third test will be with the turns scrunched up to occupy only 180° of the toroid circumference. We will start out with the two previously mentioned instruments that you just made, as shown in Figure 11, Test Setup. We will want to test at two frequencies, the second one double the first. So, F1 will be 7.0 MHz and F2 will be 14.0 MHz. We need to calculate the approximate capacitance that it will take to achieve resonance so we will use the following formula (many times, later):

$$C_{pF} = \frac{25330}{(f_{MHz}{}^2)\cdot(L_{uH})}$$

Note that C is in pF, f is in MHz and L is in uH.

So, for a starting point, let $f = 7$ and $L = 1.1$, then $C \approx 469$ pF. Because of self capacitance, C_0 and other parasitic elements, it best to start with a little less, you

need to subtract from that the variable that you are using, which in this case is a maximum of 28 pF. We will then change the frequency to 14 MHz and make the same measurements. The expected value of C2 will be something less than C1 divided by 4. We will test the same coil in three configurations, turns evenly spaced over the full length, with a 30 degree gap and with the turns scrunched up to only cover 180 degrees of the toroid.

From the two measurements we make we will calculate the inductance and self capacitance of the coil. In addition, at each frequency we will measure the –3 dB points on each side of the center frequency. The data points we will work with are F1, C1, F2, C2 and $F_{L-3\,dB}$, $F_{H-3\,dB}$ from the center frequency F_c. Here are the calculations, with the caveat that F1 is always the lowest frequency and F2 is the highest frequency:

$$C_0 = \left(\frac{C1 - (4 \cdot C2)}{3}\right)$$

C_0 is the self capacitance of the coil. Then to find the true inductance of the coil we use:

$$L = \left(\frac{25330}{(f^2)(C + C_0)}\right)$$

We will do this twice, once with F1, C1 and C_0 and then a second time with F2, C2 and C_0. I usually write out the results to at least 5 or 6 decimal points. The accuracy is not needed, but, if the calculation of L1 matches the calculation of L2 to that degree of accuracy, I can feel good about the measurements. If they do not agree, then I have made a measurement error somewhere, in the capacitance or center frequency. After those calculations have been made, and while at each of the frequencies, F1 and F2, the bandwidth and calculated Q are also measured. The simple formula for that calculation is:

$$Q = \left(\frac{f_c}{f_h - f_l}\right)$$

where f_c is the center frequency and f_h and f_l are the –3dB points in frequency from the center frequency. When using the meter for the above measurements, the actual value is not important. I usually adjust the signal generator input for an output, at resonance, of about –20 dB on the RMS voltmeter. Then the high and low frequencies would be at –23 dB. The actual value is not important, just that you have measured the frequency at each of the –3 dB points. Two of the coil configurations are shown in Figures 12 and 13.

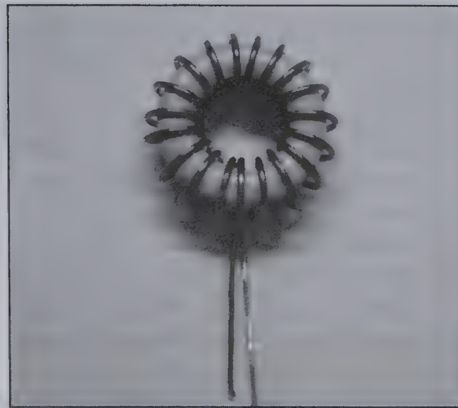


Figure 12—Coil with turns evenly spread around core.

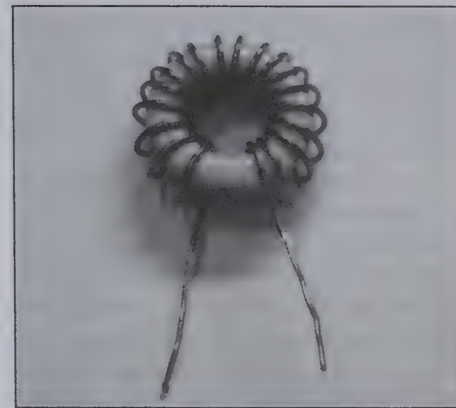


Figure 13—Coil with 30 degree gap between winding ends.

Data Category	Full Coil	30° Gap	180° Gap
$C1_{pF}$	450	440	388
$C2_{pF}$	108.1	105.2	92
$C_{0\,pF}$	5.86666	6.40000	6.66666
F1 -dBm	-23.8	-24.0	-23.3
F2 -dBm	-13.5	-13.3	-13.4
$L1_{uH}$	1.133969	1.158017	1.309811
$L2_{uH}$	1.133969	1.158017	1.309811
Q_7	104.790	103.857	111.98
Q_{14}	172.626	177.665	173.05

Table 1—Data from measurements of coil with three winding spacings.

Capacitor Type	-dBm	Q (of Standard Coil)
Sprague Goodman SMT (V)	-13.4	176.99
JFD Glass Piston (V)	-13.7	168.87
SG-1014 Green Ceramic (V)	-14.3	155.21
Green Metal Plate Poly Ins. (V)	-13.5	174.56
Xicon Ceramic Trimmer (V)	-14.0	162.7
Johnson Air Variable	-13.5	176.32
100 pF Dipped Mica-Fixed	-12.9	182.39
100 pF Polystyrene	-13.7	173.56
100 pF Mono Ceramic Disk	-17.4	14.38
100 pF SMD X7R	-14.6	155.18

Table 2—Measurement of coil Q with various capacitor types.

All the measurement data with the three coil configurations are summarized in Table 1.

The following conditions apply: F1 = 7.00 MHz, F2 = 14.00 MHz

From these measurements you could conclude: The spacing on the coil has no significant effect on the Q of the coil. In addition, the implication that squeezing the coil turns together or apart do not actually

change the inductance, but the self capacitance which results in an apparent inductance change. Well maybe a small change in inductance also? The dBm output of the measuring circuit is indicative of Q.

Now, there is a third "everybody knows" and standard rule of thumb: Don't worry about capacitors. Their Q is always so high, they have no effect on the circuit Q. Now, that may be the case if the circuit Q is 50, but when you are at 100 or 200 or more, the capacitance type and selection certainly has an effect. It may be small, but it is still there. In fact, if you look as some capacitor data sheets you will find guaranteed minimum Qs as low as 100 or 500. In selecting a new variable capacitor to be used with the current test boxes described above, I measured the effect of several variable capacitors and then lastly, to fill in the data knowledge, a few types of fixed capacitors. The measurement results are summarized in Table 2.

So it is clear that capacitor types do affect the Q, albeit not a great deal. If you take the dipped mica as the best case and add in parallel the Sprague Goodman SMD trimmer (which is what is used for these tests) you can calculate that the Q of the Sprague trimmer is 5,978, which is pretty good. The GSX366 which I am using is specified to have a minimum Q of 1000 at 10 MHz.

My conclusions on the three items in question:

1. Spacing of turns on toroid has little to no effect on the Q.
2. Changing turns spacing changes apparent L mainly due to self capacitance change.
3. Capacitor Q can and does make a difference to circuit Q.

●●

REF-DES	Value	Part Number	Price-ea.
B1	9V		
C1, C3, C5	100nF	399-4329	$0.33
C2, C4	10nF	399-4206	$0.24
D1	RED LED	1080-1058	$0.44
J1, J6	BNC	367-1019	$4.08
J2, J3	Bind Post	J164/J165	$4.67
J4, J5	Ban Jack	J151/J152	$0.70
Q1, Q3	J310G	J310GOS	$0.55
Q2	2N3906	2N3906FS	$0.20
R1	49.9	CMF49.9QFCT	$1.04
R2	0.01	73M1R010FCT	$0.80
R3	10Meg	10MQBK	$0.10
R4, R5, R8, R9	1K	1.0KQBK	$0.10
R6	100	100QBK	$0.10
R7	1Meg	1.0MQBK	$0.10
R10	4.7K	4.7KQBK	$0.10
SW1	OFF-ON SW	432-1143	$2.30
Case	LMB CR-421		

Bill of Materials for the L-Q Meter.

REF-DES	Value	Part Number	Price-ea.
B1	9V		
C1	15pF	478-3161	$0.31
C2, C7	10nF	399-4206	$0.24
C3, C4, C6	100nF	399-4329	$0.33
C5	10uF	478-1840	$0.95
D1	RED LED	1080-1058	$0.44
DISP	DMS-20LCD-0-5-C	811-1014	$32.00
J1	RF IN BNC	367-1019	$4.08
L1	2T 3/16 ID		
R1	470	470QBK	$0.10
R2	200K	200KQBK	$0.10
R3	10K	10KQBK	$0.10
R4	390	390QBK	$0.10
R5	56K	56KQBK	$0.10
R6	1K	1.0KQBK	$0.10
R7	1.5K	1.5KQBK	$0.10
R8	5.1K	5.1KQBK	$0.10
R9	2.2K	2.2KQBK	$0.10
SW	OFF-ON SW	432-1143	$2.30
U1	AD8307	AD8307ARZ-RL7CT	$13.50
U2	LP2980	LP2980AIM5-5.0NOPBCT	$0.71
Case	LMB CR-421		

Bill of Materials for the RF RMS Voltmeter.

The $20 Arduino SWR Analyzer

Ben Kuo—KK6FUT kk6fut@verizon.net
Pete Juliano—N6QW radioguy90@hotmail.com

The authors of this article, N6QW and KK6FUT, were fortunate to have met through a random QSO on 20 meters last year, and learned that they were both into home brewing—and happened to live just a few blocks away, in the same town. Even more serendipitously, we found out we had complementary skills for a whole host of homebrew projects, with one of us (the beginner, KK6FUT) having had a professional background in embedded software, the other (the veteran, N6QW) a long and deep knowledge of radio hardware. In this latest article, we've again combined that expertise for a new project, the $20 Arduino SWR Analyzer.

In any ham radio installation, it's not just the radio that is important—as important, or maybe even more important, is your antenna. One of the handiest tools to have in a ham's toolbox is an SWR analyzer, so that you can really tell what is going on with your antenna installation. Whether your build your own antenna (the authors heartily vote for that, in the spirit of home-brewing)—or even if you buy an antenna—being able to measure what that antenna is doing and make adjustments to improve your antenna, cannot easily be done without that handy tool, the antenna analyzer.

In this project, we'll outline a simple Arduino-based antenna analyzer, which you can easily put together for what we estimate is around $20, which pretty much performs as well as commercial analyzers costing $200 to $300. We'll also explain how it all works, so that not only can you build your own Antenna Analyzer—if you are ambitious, you can enhance the code and expand this project well beyond the basics, to include sweeping your antenna through the band, exporting data to your PC for analysis, or even creating a graphical analyzer—all based on the same platform. For now, we offer up a simple, easy-to-build and use antenna SWR analyzer which lets you dial into your favorite HF band and frequency, and read back the SWR at that frequency.

This project does not pave new territory in terms of hardware and software design; we've liberally borrowed from the available resources (most notably, K6BEZ's Creative Commons antenna analyzer circuit, and the public domain Arduino DDS examples offered by MØXPD), for this project. However, what we hope to accomplish here is to show the reader how a few, readily available—and inexpensive—components can allow you to build your own, simple HF antenna analyzer. As a bonus, we help you understand how it works, including at the software level. There's a big emphasis here on keeping this simple, and there are only 11 resistors, 2 diodes, 5 capacitors, and one IC op-amp in this hardware, plus the Arduino, a DDS module, LCD module, and a rotary encoder for input. A completed project and interior view of the project is shown in Figures 1 and 2 below.

Reminder: SWR And Antennas

As a reminder to those beginners who might tackle this project (one of the authors, KK6FUT, pretty much qualifies in this regard) SWR or Standing Wave Ratio is a calculation of the standing waves in a transmission line that reflect the amount of RF energy passing from your rig to the antenna via the transmission line as compared to the amount being reflected back from the antenna through the transmission line back to the transmitter. The important thing that hams all know is it's important to get as close to a 1:1 SWR (sometime referred to as an SWR of 1.0) as possible on your antenna—meaning that all of the power being sent out of your transceiver is being transmitted by the antenna, rather than being reflected back into the radio. *That's particularly true in QRP, where we need every last bit of RF we can get out to the antenna and into the air!* Anything other than 1:1 results in power not headed toward the antenna! Most hams strive to have antennas with a less than 1.5 SWR, and most radios can only handle up to 3.0 SWR before they start drastically reducing power to prevent permanent damage to your radio.

There are two ways to reduce SWR at your radio. Most long time hams do this by adjusting their antenna—extending or shortening their antenna in the case of a dipole—to best reduce the SWR; some others prefer instead to use a tuner to tune a high SWR antenna down to a more rea-

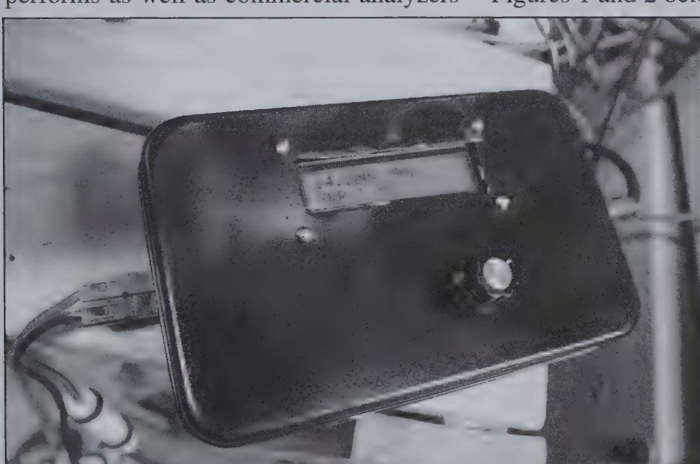


Figure 1—Completed project reading out SWR on a homebrew 20M antenna.

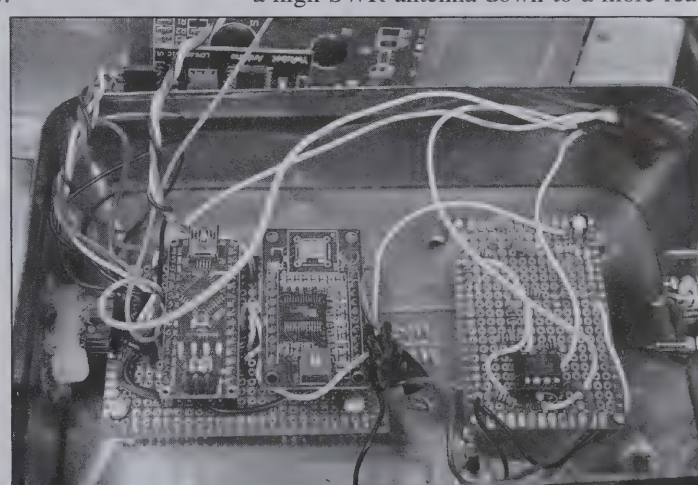


Figure 2—Interior of the SWR Analyzer.

sonable level (although that really tends to mask, rather than cure, antenna performance problems). In either case, however, an antenna analyzer is a key tool to that SWR adjustment.

The Advantages of Low SWR

A low SWR has three major benefits:

1. Energy losses are minimized with the lowest SWR: "More Signal into the Antenna!"
2. Distortion to the signal is reduced and/or eliminated. (RF Feedback problem.)
3. Prevents damage to your equipment resulting from high SWR. That is why many of the better transceivers have built in SWR sense circuitry that automatically reduce the power input when the SWR exceeds 3:1. Some even have built in antenna tuners not because the manufacturers are kind -it's to protect their equipment and reduce warranty costs. Too high of an SWR causes solid state finals to overheat which then will dramatically shorten their life. A pair of matched finals are well over $100 and for about 25% of that cost you can build this tool.

First, A Simple Circuit For Measuring SWR

We mentioned that SWR is a calculation but first we should mention that there are three types of SWR, those being Voltage (called VSWR, usually pronounced *viswar*), Current (ISWR), and Power (PWSR) which is nothing more that the squared values of the VSWR voltages. Of the three, the VSWR seems to be the most commonly used. Some commercial Power/SWR meters such as the Drake WH-4, provide a nomograph card so that by measuring the forward power in watts and the reflected power in watts the SWR can be accurately read from the card.

In our case, we are using VSWR. Happily for us, K6BEZ has provided a simple circuit to measure the forward and reflected voltage into an antenna and feed it into a microprocessor—in our case, the Arduino. We've made a couple of simple changes to K6BEZ's earlier design, to suit some of our preferences.

So here's the math: in order to calculate VSWR, we need to take two values that we're reading—forward and reverse voltage—and run a calculation:

$$VSWR = (FWD + REV)/ (FWD - REV)$$

By inspection if you had 20 volts forward and 10 volts reverse then the VSWR = 30/10 = 3:1. Most of today's commercial transceivers, of good design, will drastically reduce power or shut down when the SWR reaches this level. Taking this to an extreme if the FWD voltage is the same 20 volts and the REV is 20 volts then you have a case of VSWR = 40/0 = infinity.

Readers who are familiar with the Heathkit HM-15 and simple meter-type, SWR bridges, might recall this used to be done using a simple meter. Those SWR bridges used a directional coupler comprised of a pickup loop inserted near the transmission line, where several diodes rectify the forward and reflected voltages being sensed and subsequently display that on a sensitive meter. Typically how these manual bridges operate is to adjust the antenna and/or antenna tuner such that you have the maximum forward reading and the minimum reverse reading which results in the lowest SWR. Unless some special treatment is given to these measured voltages you are not reading actual SWR directly but simply conditions that result in a low SWR. With this project, we've eliminated all of those manual steps and have the Arduino automatically doing that for our antenna. We then output the end result—the actual SWR reading itself.

We made a number of changes to K6BEZ's SWR circuit. Among those changes was the switch to using 1N270 diodes instead of 1N34 diodes, due to some issues one of the authors, KK6FUT, ran into during building the prototype for the analyzer. (He managed to fry four 1N34's in building the project due to his sloppy beginner's soldering skills. Beginner's tip: make sure you heat sink your diodes with pliers or other tool, to avoid damaging the diodes due to the heat of a soldering iron!) The 1N270's are slightly more robust, and is what was ultimately used in the successful analyzer pictured above.

Now that we know how to go about measuring the SWR, we can build our Antenna Analyzer around that measurement.

Creating An Antenna SWR Analyzer

In Figure 3, we show the block diagram of the project. We are using the SWR circuit above and a DDS module, tied together the Arduino and a few other parts to make our complete SWR Analyzer. We'll go into more depth on each of these blocks further on in the article, but for now, here are the major components:

- Arduino. The brains of the Antenna Analyzer is the Arduino, a popular, open source, embedded system which is being used to program thousands of different kinds of projects of all kinds. It has also become popular for ham radio projects. Versions of the Arduino are now being sold on sites like eBay for less than $2.50!
- Rotary encoder. Instead of a serial port or other interface, we've chosen to use a rotary encoder to take input from the user. The rotary encoder interfaces with the Arduino to allow us to figure out if we want to increase or decrease the frequency we are measuring. Plus, it also

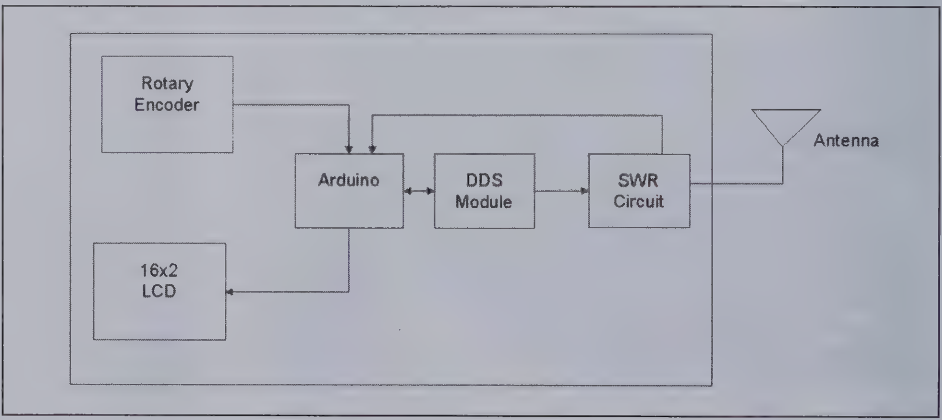


Figure 3—Project block diagram.

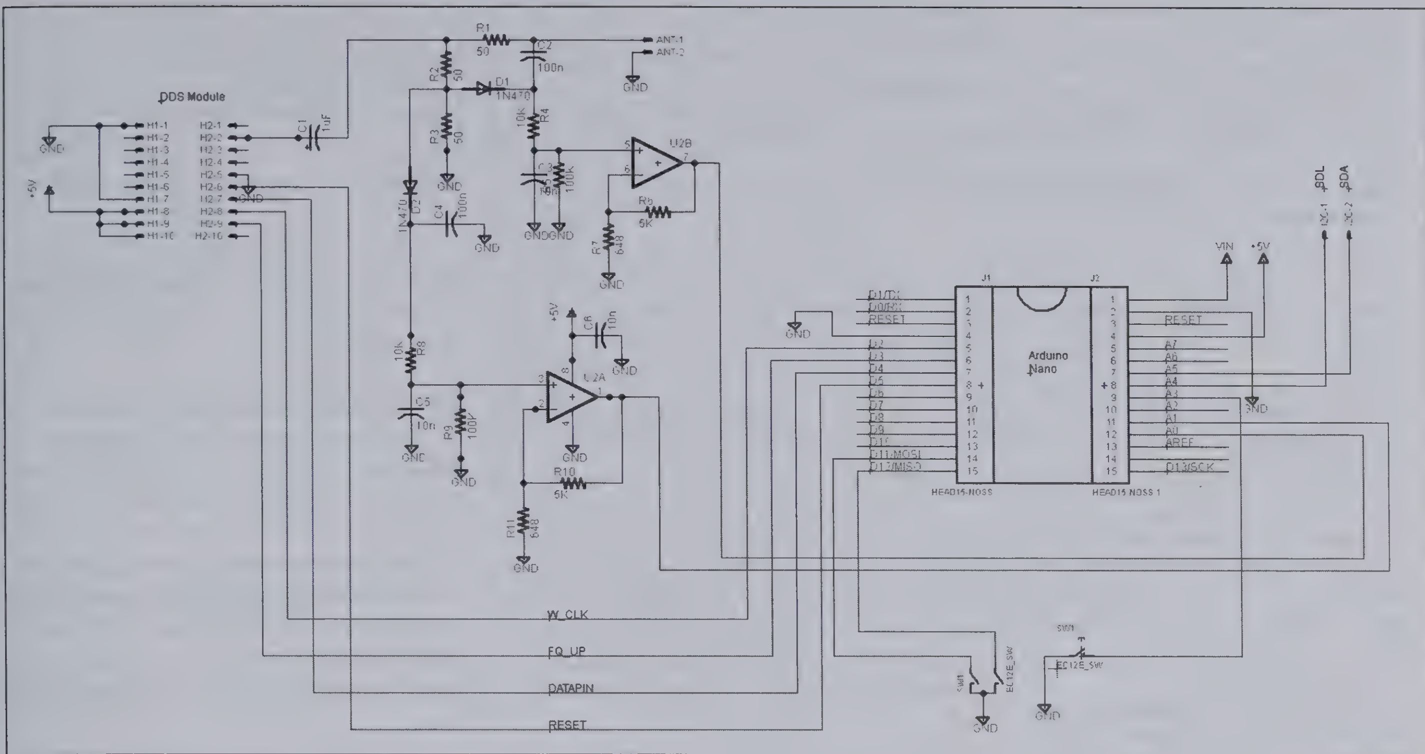


Figure 4—SWR Analyzer schematic.

acts as a push button, which we use for only one function—as a band switch, letting us go to the next band.

- 16x2 LCD. For output, we've included the use of a 16x2 LCD, which is the most inexpensive LCD you can connect to the Arduino. For ease of connections, we're using the I^{2}C version of an LCD, which allows you to connect and fully program the LCD using only four wires, including power and ground.
- DDS Module. Another component which has enabled many ham radio projects is the DDS (Direct digital synthesizer), which is based on an AD9850 DDS module is widely available on the Internet for around \$6 to \$10. We've selected the most basic DDS module available which lets us handle all of the HF bands. There is another equivalent module which uses the AD9851. It can be used up to 2m (144 MHz band). With this current project, we are focused on an HF analyzer—although it should work with up to 2m frequencies by switching to the more expensive module (between \$18-20). We're not handling the intricacies of higher frequencies than that here.
- SWR Circuit. This is the SWR measurement circuit, as outlined above.

The Arduino Driven DDS

As part of the analyzer, we need a signal source to put our frequency onto our antenna we are testing. Fortunately for us, one of the more popular projects nowadays for homebrewing is the DDS—a chip which eliminates the many hassles of crystal-based VXOs and supports a very wide range of frequencies, is rock solid stable, and can be applied to many different projects. Rather than deal with creating a wide ranging frequency generator using analog components, we've taken advantage of the widespread availability of AD9850 and AD9851 modules on the market for this project, which involves simply connecting up four control lines to the DDS module to specify the desired frequency. You can use other, similar AD9850 modules, simply adjusting for the wiring and headers for your specific model of module. All of the AD9850 modules—or, your own AD9850 design, for that matter—communicate with the chip using four pins: W_CLK, FQ_UD, DATAPIN, and RESET. In our version, we connect these to pins 2, 3, 4, and 5 on the Arduino. These pins also need to be declared in our software code, specifically in the "setup" routine for Arduino (as shown below).

In order to program the DDS, we've used a built-in Arduino interface function call, shiftOut, which shifts the data to the DDS. The function call enables us to reliably program the DDS every time, by going through the correct procedure for manipulating the control lines. We've borrowed liberally from MØXPD's VFO source code here to program the DDS. This routine, shown in Figure 7, takes the fre-

```
//======================================
// HARDWARE: Arduino I/O Pin allocations..
// set pin numbers:
// AD9850 Module....
const int W_CLK = 2;
const int FQ_UD = 3;
const int DATAPIN = 4;
const int RESET = 5;
```

Figure 5—Setting up constants referring to pins by name instead of number.

```
// set up the pins for the DDS
pinMode(FQ_UD, OUTPUT);
pinMode(W_CLK, OUTPUT);
pinMode(DATAPIN, OUTPUT);
pinMode(RESET, OUTPUT);
// start up the DDS...
pulseHigh(RESET);
pulseHigh(W_CLK);
pulseHigh(FQ_UD);
```

Figure 6—Setting the Pins to use with the DDS.

```
// calculate and send frequency code to DDS Module...
void sendFrequency(double frequency) {
  int32_t freq = (frequency) * 4294967295/125000000;
  for (int b=0; b<4; b++, freq>>=8) {
    shiftOut(DATAPIN, W_CLK, LSBFIRST, freq & 0xFF);
  }
  shiftOut(DATAPIN, W_CLK, LSBFIRST, 0x00);
  pulseHigh(FQ_UD);
}
```

Figure 7—sendFrequency Function Call.

```
// set up our inputs for the rotary encoder
pinMode(RotEncAPin, INPUT);
pinMode(RotEncBPin, INPUT);
pinMode(RotEncSwPin, INPUT);
// set up pull-up resistors on inputs...
digitalWrite(RotEncAPin,HIGH);
digitalWrite(RotEncBPin,HIGH);
digitalWrite(RotEncSwPin,HIGH);
```

Figure 9—Setup of the pin behavior.

```
// Read the inputs...
RotEncA = digitalRead(RotEncAPin);
RotEncB = digitalRead(RotEncBPin);
RotEncSw = digitalRead(RotEncSwPin);

// ====================================================================

if ((RotEncA == HIGH)&&(OldRotEncA == LOW)){
  // adjust frequency
  if (RotEncB == LOW) {
    freq=constrain(freq+10000,BandBases[bandindex],BandTops[bandindex]);
  }
  else {
    freq=constrain(freq-10000,BandBases[bandindex],BandTops[bandindex]);
  }
```

Figure 10—Reading the Rotary Encoder (snippet).

```
if (RotEncSw==LOW){
  // if user clicks rotary encoder, toggle band to next settingfs
  bandindex = (bandindex+1)%11; // change the band to the next one
  freq=constrain(freq,BandBases[bandindex],BandTops[bandindex]);
  // make sure we don't go outside band
  LCD_Display_Freq(freq); // show the new frequency
  sendFrequency(freq); // set the new frequency
  delay(400); // delay after setting frequency
}
```

Figure 11—Checking Rotary Encoder Switch for Next Band Signal.

```
// Instantiate the LCD display...
//LiquidCrystal lcd(0x27); // Adafruit I2C
LiquidCrystal_I2C lcd(0x027, 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE);
// Set the LCD I2C address TwRobot
```

Figure 12—Setting up the LCD Library.

```
//  lcd.begin(16,4); //Adafruit I2C
lcd.begin(16,2);   // initialize the lcd for 16 chars 2 lines,
turn on backlight TwRobot
```

Figure 13—Initializing the LCD in setup().

```
// Rotary Encoder...
const int RotEncAPin = 11;
const int RotEncBPin = 12;
const int RotEncSwPin = A3;
```

Figure 8—Assigning the pin numbers.

quency we need to program the DDS and properly calculates the right bits to send out to the DDS.

Using a Rotary Encoder

The user interface for this project is a rotary encoder, which works by sending pulses to the Arduino when the user turns the knob clockwise or counterclockwise. It also has a momentary switch function. We use three pins for reading the current state of the rotary encoder, and use some simple logic to determine if the rotary encoder is being turned clockwise or counterclockwise.

As we do in all of these projects, we first set up a constant value to represent the pin numbers—so we can use names, rather than numbers, in our code, for the pins. That's shown in Figure 8.

Next, we tell the Arduino to make these pins inputs, and also—importantly—use built-in, pull up resistors on all these pins in order to make the rotary encoder work.

Finally, in our loop segment, we use digitalRead to read the state of the pins, and use a bit of logic to determine the direction of the rotary encoder and whether or not the switch was pressed. Due to space constraints, we'll let you puzzle through this code to decode the logic of the rotary encoder. We also check for a click of the momentary switch in the rotary encoder, and use that as the command to switch to the next band in sequence.

I See The LCD

In one of our prior projects, CW Sender Part III, we introduced the concept of using an LCD with the Arduino. For those who did not read the article, the Arduino includes a number of libraries to handle LCD displays. Those displays can either interface directly to a number of connections on the Arduino, or you can also connect those LCDs through a four wire I^2C interface. We've taken advantage of the I^2C interface, plus a 16x2 line, I2C-powered display for this project, to simplify interconnection of components. Important

```
// subroutine to display the frequency...
void LCD_Display_Freq(double frequency) {
  lcd.setCursor(0, 0); //was 17
  if (frequency<10000000){
    lcd.print(" ");
  }
  lcd.print(frequency/1e6,4);
  lcd.print(" MHz");
  // establish the cursor position
  int c_position=25-dfindex;
  lcd.setCursor(c_position, 0);
  //lcd.blink();
}

void LCD_Display_VSWR(double swr) {
  lcd.setCursor(0, 2); //was 17
  lcd.print("SWR ");
  lcd.print(swr);

}
```

Figure 14—Display Routines for LCD.

```
// Calculation of VSWR using two voltage levels
void Calc_VSWR() {
  // Read the forawrd and reverse voltages
  REV = analogRead(SWRA);
  FWD = analogRead(SWRB);
  if(REV>=FWD){
    // To avoid a divide by zero or negative VSWR then set to max 999
    vswr = 999;
  }
  else{
    // Calculate VSWR
    vswr = (FWD+REV)/(FWD-REV);
  }

}
```

Figure 15—Routine for calculating VSWR.

```
// Now, update the LCD with frequency and recalculate VSWR
LCD_Display_Freq(freq); // push the frequency to LCD display
sendFrequency(freq);  // set the DDS to the new frequency
delay(400); // let the frequency/voltages settle out after changing the frequency
Calc_VSWR(); // routine to calculate VSWR
LCD_Display_VSWR(vswr); // push the values to the LCD output
```

Figure 16—Main Update Routine.

note: LCD libraries on the Arduino are notoriously un-standardized, and might require you to load a special library depending on whose I^2C hardware you are using; because of that, the source code for setting up the LCD library could be significantly different depending on the LCD/I^2C vendor.

To set up the LCD, we simply include two lines of code: one to include the LCD library, and the other to initialize the LCD. You'll note we have two different ways of setting up the Arduino lcd library (one is commented out)—due to the variances in LCD libraries in Arduino.

Finally, we are using a number of routines to display our frequency and SWR on our LCD, shown in Figure 14. Luckily for us, the use of the LCD—once you have it set up on Arduino—does not change.

Reading and Calculating SWR With Analog Inputs

Finally, the last piece of the puzzle is doing the reading and calculating of the SWR, using the two analog inputs, A0 and A1. The analog inputs on the Arduino provide a digital value of the voltage on the pin—perfect for reading the voltage from our two diodes. The Arduino uses the function analogRead() to convert any voltage between 0 and 5 volts into a digital value of between 0 and 1023. However, for this application we actually do not care what the digital value is because the VSWR math is relative between the two readings. As long as we get a value between 0 and 5 volts, we can calculate the VSWR. We actually take this routine directly from an example program given to us by K6BEZ.

Read, Recalculate, Repeat

Now that we have all the pieces put together, our main loop is now just read, recalculate, and repeat. We keep on checking for input from the rotary encoder, in case the user of the analyzer wants to go up or down in frequency or wants to switch a band. And all the while, we set the new frequency and read back our SWR value, outputting it to the screen until the user pulls the plug. The main update routine is shown below, and the full code is on the website:

Future Expansion

This project provides the basics of a SWR analyzer. Some future expansion you can do to this project, which we might tackle in future articles—or you can do yourself are:

- Sweep of a band to figure out the "sweet spot"
- Export SWR data for any band to a PC for graphing
- PC software to profile any antenna across all bands
- Graphical output of SWR to an LCD; curve graphing in the field
- Support for VHF SWR metering

Summary

In this project, we've outlined a simple project which gives you a fully functional, Arduino-based SWR analyzer, which you can carry out into the field and use to check out any antenna. This low cost project takes the guesswork away from figuring out if your antenna is set up correctly, and is resonant on the frequencies you are operating on. It is idea for portable operation, Field Day, and even at home for testing out your home antenna installation. In addition, the project gives you a great introduction to some useful, Arduino-based components—the LCD, rotary encoder and DDS—which can be used for other ham radio projects.

●●

Two Audio Sine Wave Oscillators

Phil Anderson—WØXI

aldenmcduffie@sunflower.com

Two Oscillators: The 700 Hz Quadrature and the PIC R-2R

Most of the code practice or bench oscillators posted/offered use the ubiquitous 555 timer chip. That's not a surprise given that it's well known and long standing. A slight problem, however, is that the output is a near square wave and thus includes a heavy dose of its third harmonic; the result is raspy sounding and distracting. In addition, most circuits featuring a sine wave add complexity and have a low output voltage. One example is the 3-stage RC phase-shift oscillator. By comparison, the quadrature and PIC R-2R presented here are relatively simple and provide full rail-to-rail (supply) voltage output with little distortion.

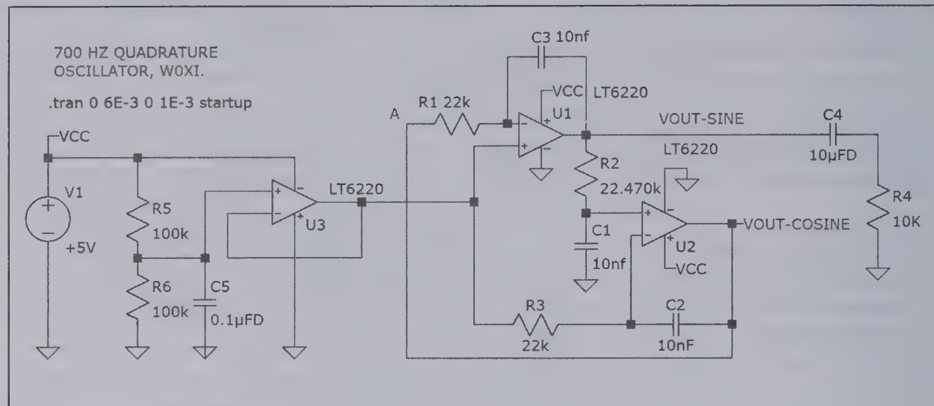


Figure 1—Quadrature oscillator schematic.

Quadrature Oscillator

Let's start with the 700 Hz quadrature sine wave oscillator. Keep in mind that, with a change in R and C values, any other single frequency can be established. The version I simulated, wired and tested is shown in the schematic of Figure 1. Figure 2 is my breadboard version of the quadrature oscillator. It features a single supply, 700 Hz oscillator, and is AC coupled to a 10 kohm load resistor, R4. One could replace R4 with a potentiometer and drive an LM386 or similar audio amplifier or load the tap of the pot with a 10 kohm resistor in parallel with a crystal ear piece.

While not shown, I used a 9 V battery and +5 V low dropout regulator (2950) for the + 5 V supply, shown at left as VCC. Bias is established for U1 and U2 using an op-amp follower, U3. The oscillator consists of two op-amp sections (in the same package), U1 and U2, three 22 kohm resistors and three 10 nF capacitors. An arbitrary 10 kohm load is shown along with a decoupling capacitor, C4. A sine wave output of 5 V peak-to-peak (V_{p-p}) (biased at 2.5 V) is produced at U1 as shown in the top trace of the scope picture in Figure 3. A quarter-wave delayed "cosine wave" is produced at the output of U2 at the bottom. As such, the circuit is known as the quadrature oscillator.

Detail readers will note that the value of R2 as labeled in the schematic is 22.470 kohm rather than just 22 kohm. I noted in testing—and in web articles about this oscillatorñthat the resistors need to be matched while R2 needs to be a bit more than R1 and R2 to guarantee that the circuit will oscillate. I figured the usual 2% rule applied here and it does. 2% of 22 kohm is 440 ohms, so I added a standard 470 ohm resistor in series with R2; hence we get the 22.470 kohm in the schematic.

Articles say that it's a good idea to use 1% resistors for R1 through R3. While 1% tolerance 10 nF capacitors would be a

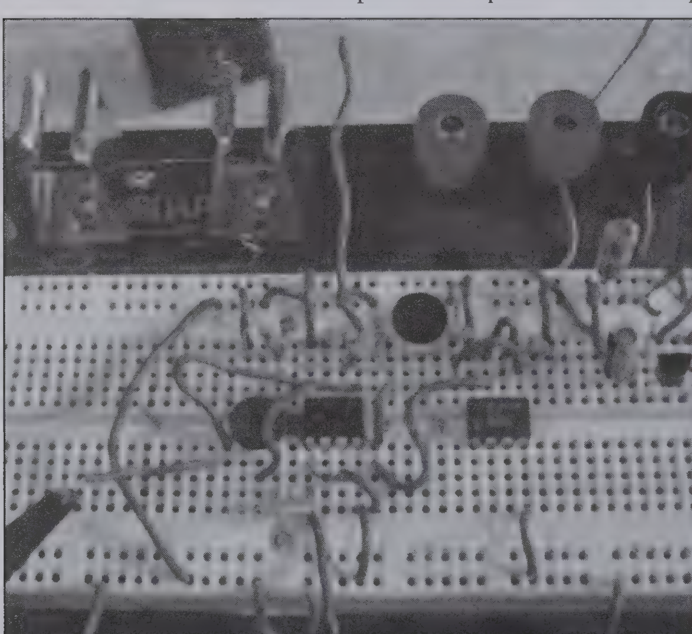


Figure 2—Quadrature osciilator breadboard.

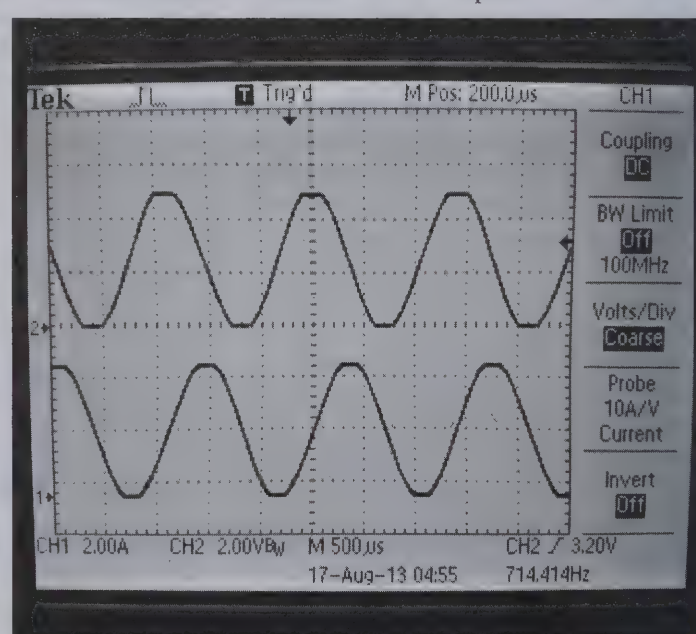


Figure 3—Scope trace of the quadrature oscillator output.

good idea too, I noted that Mouser prices for the 1% caps as compared with the 10% caps is more than $3.00 compared with less than 10 cents! So I used my handy BK Precision 810C capacitance meter to find three 10 nF caps at about 98% or better, i.e. less than 2% off. This oscillator has not failed to start using these minor adjustments. It will not start if R2 is less than the 22 kohm value of R1. Table 1 lists R and C values for several frequency choices. 1 kHz is popular for those desiring a test oscillator. If you wish to have a standard 8 ohm output, then put a potentiometer in place of the 10 kohm load in the schematic and add a LM386 audio amplifier to the output. A 9 V battery will more than power this setup.

Again, the detail reader may notice the LED at upper right in my test bench picture. I always add one in series with the 9 V battery, 1N914 diode and 4.7 kohm resistor. The LED reminds me to disconnect the battery when leaving the bench! Those darn expensive 9 V batteries!

Detail on the 700 Quadrature Oscillator

Skip this section if you don't care to know "why?" the circuit does what it does. It's not as straightforward as the more familiar three RC phase-shifts audio oscillator. If my explanation doesn't suit you, then consider reading the TI application note referenced below.

One way to shake down the operation of an oscillator is to start at any signal point (node) in the circuit and work your way around the circuit until you return to your starting point, noting hopefully that the return voltage matches up with your starting voltage in amplitude and phase—hence oscillation. This idea is known by old-timers like me as the Barkhausen Condition. In addition let's assume that the absolute value of the reactances for C1, C2 and C3 are all equal and equal to the value of the resistors at our chosen frequency of operation.

To show that the circuit will support oscillation, my example starts with the voltage at the output of U1, pin1, labeled VOUT-SINE.

1. To keep the math simple, I arbitrarily chose the peak of the volt there to be 1 V at a phase angle of zero.

2. This voltage drives the voltage divider R2-C1 at center and since the + input impedance of op-amp U2 is infinite, the output of the divider acts normally, reducing the signal from U1 by 0.707 and adding an additional phase delay of 45 degrees. (Remember Xc = R).

Frequency	R	C
Roughly 1.6 kHz	10kΩ	10 nF
1 kHz	15kΩ	10 nF
700 Hz	22KΩ	10 nF

Table 1

3. Since U2 has a feedback divider at its output and the (–) input is high Z, the voltage there is made equal to the (+) input. Hence, the output of U2 boosts the input by square root of 2, or 1.414, thereby restoring the voltage in the previous stage of 0.707 back to 1 volt. Think of this action as a reversed isolated voltage divider. In addition another 45 degrees of phase shift is added, resulting in the signal at the COSINE output of U2, pin 1 equal in amplitude but delayed by 90 degrees with that of the sine output. This is good news since we all remember that the cosine lags the sine by 90 degrees; right?

4. Finally to support oscillation, circuit U1 provides for a unity transfer but with an additional phase shift of –90 degrees, since it is an integrator. That matches our output at U1, pin 1. Houston, we have oscillation.

PIC R-2R Oscillator

This oscillator, shown in Figure 4, produces a near sine wave output, where the signal increases and then decreases in small steps as if it was going up and down a staircase. The PIC chip by Microchip is, of course, a digital device. As such, the height of the sine wave steps are stored in a table. As time goes by the different bits of an entry in the table are shifted to the output pins. An inexpensive R-2R resistive network then converts the digital value represented by the bits to an analog output at VOUT. If the number of steps is made large and the size of the steps made correspondingly smaller, the output approaches a pure sine wave shape. Since the smaller microchips use an eight bit word the number of voltage steps is limited. Adding a simple RC filter at the output results in a nice, near-sine wave shape. The output is much closer to a sine wave than one gets using a 555 timer which produces just two steps, a square wave; and that would require multiple stages of RC to smooth it.

The period of the sine wave at VOUT is dependent upon the clock rate set for the chip, the number of bits used for each table entry and the number of instructional steps needed to complete a sine wave cycle. This means that the microchip will be barely idling, e.g. running slowly. The advantage with this simple design is that the period of the output sine wave can be varied by varying the clock rate of the chip; and, we do that by varying R10 (a potentiometer) attached to the clock input at pin 2. The main clock is dependent upon an internal inverter oscillator. As such, it's a good idea to use a mica capacitor along with the potentiometer, R10, to limit temperature

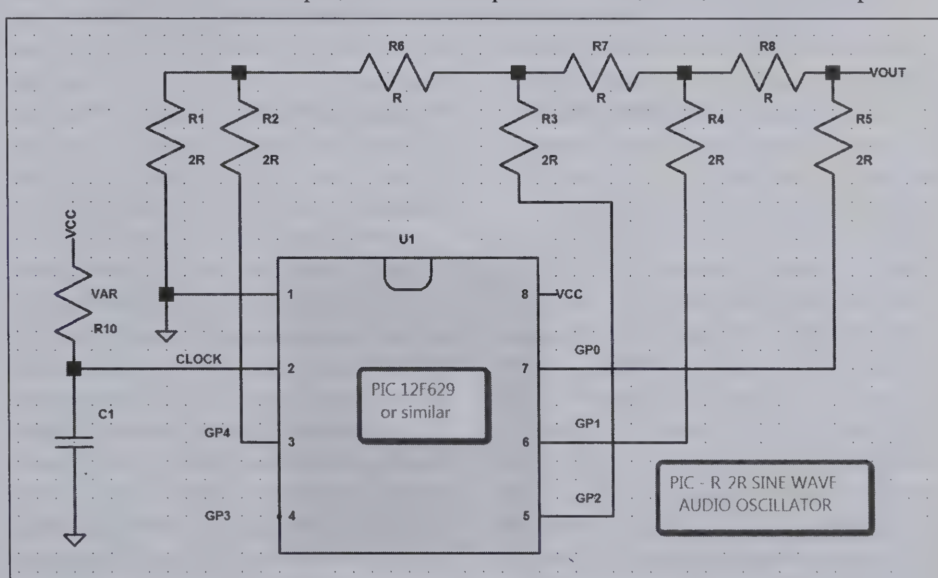


Figure 4—PIC R-2R oscillator schematic.

variations. Alternatively, one could use the internal clock, divide it down with coding, change the clock input pin into another bit for the register, and thereby use 32 bits instead of 16 bits for Vout step resolution. I don't see that that gains much and one loses the ability to adjust the frequency of the sine wave. This circuit, like all other digital and DSP configurations, is more flexible than say an analog op-amp or transistor stand-alone oscillator.

It turns out that Vout in the schematic above will be the sum of the voltages from the four output pins as follows:

Vout = GP4/16 + GP2/8 + GP1/4 + GP0/2.

If the 12F629 is powered with 5 V, a high on any one of the pins will be 5 V. Hence, when all of the outputs present 5 V, Vout will be 5*(15/16) or 4.68 V. You'll want to buffer and divide that voltage down if you're going to feed it to an audio device, such as an LM386 audio amplifier.

Rather than go over how an R-2R network works in conjunction with the outputs of a digital register, here's a tutorial web link on how the R-2R network works: http://www.tek.com/blog/tutorial-digital-analog-conversion-%E2%80%93-r-2r-dac

With a digital Micro or an Atmel chip, etc, coding for this project is pretty simple and straightforward. Microchip offers a free MPLAB development program download; this program assists you in writing the assembly line program. You then burn that program into your chip's memory. You'll set up the clock specs, configure which pins to use as outputs, and write code to set up the table and parse it out to the R-2R network at the desired rate.

—73, Uncle Phil, WØXI

References

1. LTspice, A Circuit Simulation Program you can download from Linear Technology. I simulated the first circuit shown before wiring it on the bench. It's a handy way to go to quickly change components to check operation and to experiment with a circuit.

2. TI, Application Report SLOA060 - March 2001, Page 18, the Quadrature Oscillator.

3. MC33202PGOS-ND OP-AMP, IC OPAMP DUAL, R-R LOW VOLT, BDIP, On Semiconductor. This is a rail to rail op-amp with good frequency response. I did not try any of the really old op-amps like the ubiquitous 741.

4. Biography for WØXI, 4SQRP nr 013, see QRZ listing.

Antennas 101: The External Antenna Jack

Gary Breed—K9AY

k9ay@k9ay.com

This article is a slightly edited version of the author's 2014 Four Days in May presentation, "Why Does My Radio Have a Receive Antenna Jack?"

Many amateur radio transceivers include an external receive-only antenna input as an optional feature. This presentation will explain why this extra connection is included, how it can be used, and why those extra uses are important. There will also be some examples of how radios typically have the receive antenna option wired, and how you might add this capability to a radio that does not have this particular feature. Of course, there are examples of antennas and accessories for the various uses.

Why Do I Need A Receive-Only or "Antenna IN / Antenna OUT" Jack?

The connections discussed here usually are identified as "External Receive Antenna" or "Antenna IN - Antenna OUT" jacks. Later on we'll show how the radio wiring may be different, but the basic purpose is to give you access to the receiver input without worrying about the transmitter and the power it delivers to a single Transmit/Receive antenna connector. The most common uses are:

A low band receiving antenna — The most common use is to connect a separate antenna for receiving on the 80 and 160 meter bands, where most hams have an omnidirectional (or nearly so) antenna like a vertical, inverted-L or low dipole. These antennas offer no rejection to unwanted signals, interference and noise that is arriving from directions other than the signal we want to hear. Fortunately, there have been many directive antennas developed for these frequencies that are appropriate for receiving — Beverages, EWEs, pennant, flag, K9AY loop, tuned loop and other designs. Nearly all trade efficiency for small size and/or directivity, and are not useful transmitting antennas, so they are used exclusively for receiving.

Improved reception on any band — On any band, you might get some benefit from listening on an alternate antenna, especially if your main antenna is omnidirectional, such as a vertical, or is a simple wire antenna like a dipole that has limited directivity. 40 and 30 meters share many propagation characteristics of the lower bands, and will have the greatest benefit, but directive antennas like a Beverage can be highly valuable on any of the higher bands. Or, a loop may be oriented to reduce a local noise source that is hampering your reception. Plus, most of the common receiving antennas are vertically polarized, and may detect signals that are weak or inaudible on your horizontally polarized dipole or beam.

Diversity: listening on more than one receiver — Although used for decades in commercial radio services, diversity reception has only recently become commonplace among hams. When high-end radios began including sub-receivers to monitor other frequencies, they needed an additional antenna as well. Today, quality transceivers may have a second receiver identical to the main receiver, so no performance is sacrificed while listening on either one. This important when the band is crowded with strong signals, such as in a contest or DX pileup. Diversity can be either directional (antennas listening in different directions) or polarization (e.g., horizontally polarized beam and vertically polarized Beverage).

Insert an external accessory — Commercial radio designers try to anticipate the features most hams want, but sometimes each of has a different preference! Achieving the overall receiver performance we want may require using a higher dynamic range preamplifier, a wider range of attenuation options, or fil-

ters with better rejection of unwanted signals. With access to the signal path before the rig's internal receiver circuitry, we can control the RF characteristics to suit our purposes. And of course, any external device can include a bypass switch or relay to instantly restore the radio to its normal operation.

A few less common uses include:

- Adding transverter capability to a radio
- Connection to a noise bridge "tuner tuner"
- Sharing the main antenna with another receiver
- Special test setups, such as A/B testing with a reference antenna

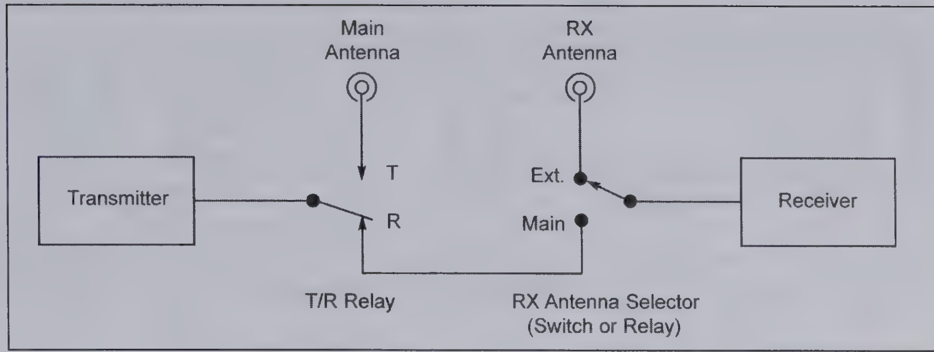


Figure 1—Simplest implementation: a switch or relay selects either the main or receive antenna.

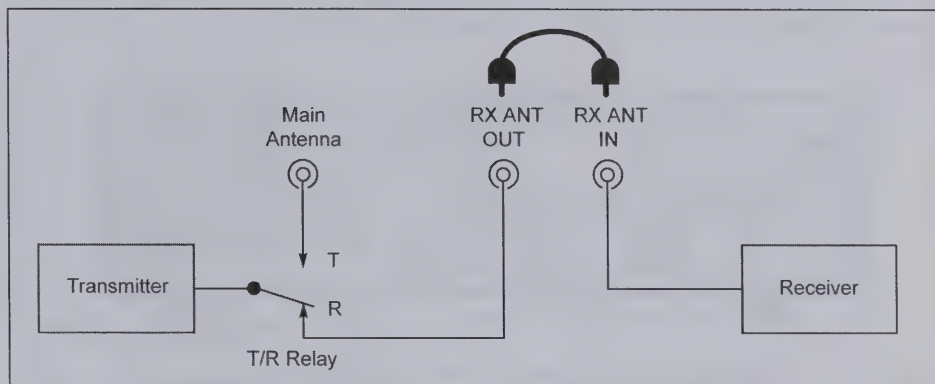


Figure 2—The RX ANT IN/OUT is a more flexible arrangement for RX antennas and accessories.

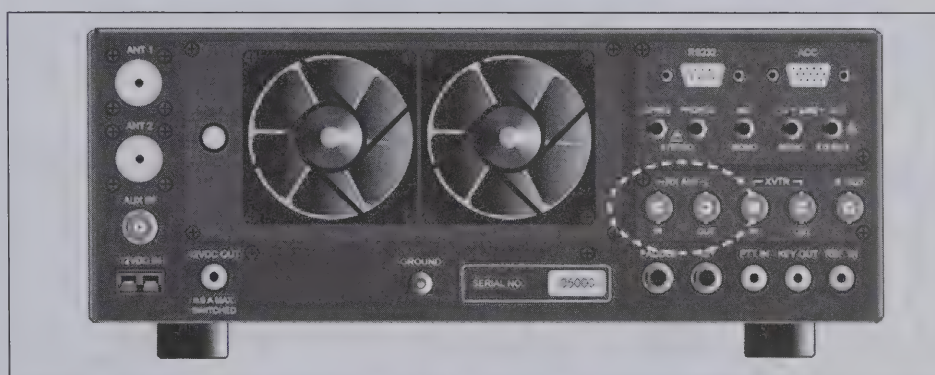


Figure 3—The Elecraft K3 includes "RX ANT IN/OUT" jacks.

How is the Jack Included in the Radio Circuitry?

There are two main ways that an external antenna jack is wired. The first is an external antenna input. A switch or relay lets the operator choose to listen on either the main (transmit) antenna or a separate receive antenna. Some radios are wired similarly to Figure 1. One of my Heathkit radios (SB-104A, I think) was wired this way, and some commercial radios of recent vintage do it this way since it is simple and low cost. While it is perfectly good for basic receive antenna use, this method does not allow the insertion of accessories like preamps, filters or attenuators between the main antenna and receiver.

The other common method for implementing a separate receive antenna uses a pair of jacks typically designated "Antenna OUT" and "Antenna IN". The basic wiring is shown in Figure 2. Following T/R switching, the coax to the receiver is interrupted to allow the insertion of an external antenna or other circuitry. When operated normally with the main antenna, either an external jumper or an internal relay provides the receiver signal path. With either method of adding RX antenna capability, the location of the T/R switch may vary. Lowpass filters, SWR sampling and an internal antenna tuner may be placed between the relay and antenna, or between the relay and transmitter.

Figure 3 shows the back panel of an Elecraft K3, which provides jacks for "RX ANT IN / OUT" connections. These jacks are part of the KXV3 board, which is shown in the upper left of the circuit diagram of Figure 4. This figure illustrates a few things about an external antenna connection. For example, the external antenna connections are in the T/R switched signal path. When the K3 is transmitting, the external antenna is disconnected from the receiver, just as the main antenna would be. This may not be the case with other radios; be sure to check the method used in yours. If the external antenna is connected to the receiver input when transmitting, there is the potential for damage if the RX antenna is too close to the TX antenna! You need to ensure that the RF pickup is not excessive.

Another item of note in Figure 4 is that the lowpass filters and ATU are in the main antenna signal path when receiving. Remember to consider the effects of these circuits if you decide to use the RX ANT IN/OUT feature for accessories that will be used with the main antenna.

Figures 5 and 6 show the back panel and switching circuitry for a FlexRadio 6700 series transceiver, which includes two SDR receivers. Each receiver has its own set of RX ANT IN/OUT jacks for full access to the radio's capabilities. Separate antennas, the transmit antenna, or various

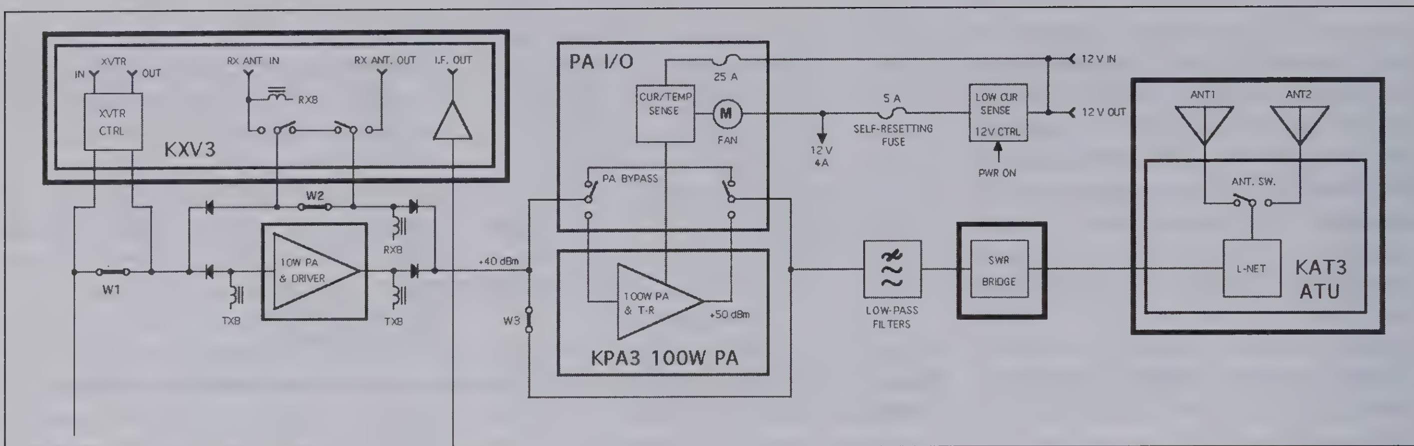


Figure 4—Elecraft K3 T/R and RX ANT wiring.

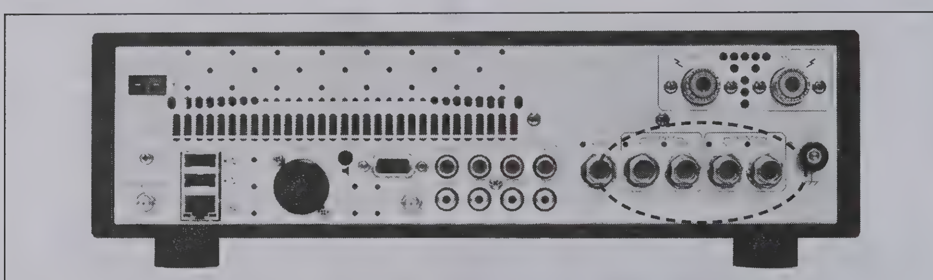


Figure 5—FlexRadio 6700 rear panel with two sets of RX ANT jacks.

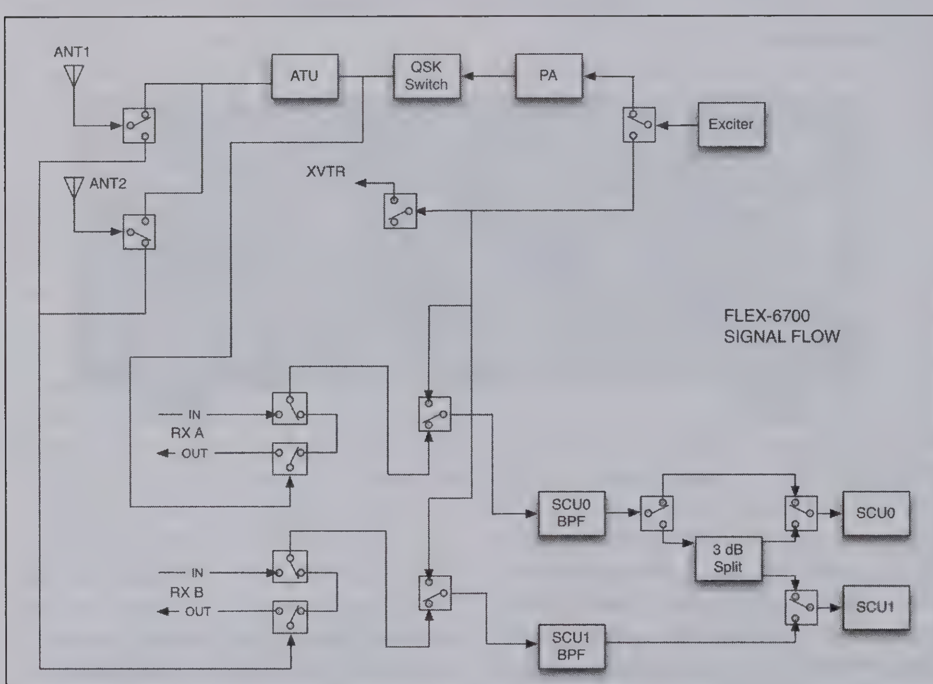


Figure 6—FlexRadio 6700 signal paths and switching block diagram.

external circuits can be included for either receiver signal path. Note that the ATU is in line when receiving on the transmit antenna, while external RX antennas are connected directly to the receivers' inputs.

Typical Receive Antenna Choices

Once you have decided to use a separate receive antenna, there are many types to choose from. For the low bands, the Beverage antenna is the best starting point for your consideration. As shown in Figure 7 below, construction of a Beverage requires 1 wavelength of wire (e.g., 540 feet for 160M), two ground rods, a matching transformer (typically 9:1 impedance ratio), a terminating resistor (300-500 ohms) and a means of support for the wire. The height of the wire may be anywhere from lying on the ground—using insulated wire of course—to perhaps 10 feet to allow people and wildlife to pass underneath. My own Beverages, which are installed seasonally in a neighboring farm field, are supported by 4-foot fiberglass posts intended for temporary electric fences. They are occasionally knocked down by deer, but I understand that those repairs will be necessary!

Figure 8 shows the directive patterns for a Beverage. The main direction is toward the right. The plot in (a) is the horizontal pattern, which has a good deep null toward the rear and very deep, but narrow, nulls off the sides. This is an excellent receiving antenna, with sufficient directivity to significantly reduce noise and interference. The only drawback is the length of the wire. Approximately 500 feet is needed for 160 meters, or 250 feet for 80 meters. I might note that shorter Beverages are possible—as short as a half-wavelength, or 270 feet on 160 meters. These shorter versions do not have the deep side nulls, but they offer a noticeable improvement compared to listening on an omnidirectional transmitting antenna.

Beverages are not the only choice, and there are many options that require much less room. Each alternative has its own set of performance characteristics, with different directive patterns, signal levels that may require a good preamplifier, and a wide range of physical and electrical com-

plexity.

Among the other receive antenna choices is the popular family of "terminated loop" structures. These include the EWE, flag, pennant, and K9AY loop antennas shown in Figure 9. Each type has a different shape and size, offering choices for installation at a particular location, but all operate on the same basic principle. These have proven to be highly useful antennas, especially with their small real estate requirements.

Tuned and untuned small loops are popular, as well. This type has a sharp null off each side. When oriented carefully, they can be quite effective at reducing annoying local interference. Construction information on these loops is included in most antenna reference books.

Arrays of multiple small antennas are growing in popularity, and are commercially available for hams who do not wish to homebrew a complex phasing and matching system. All of the loop designs are suitable for use in an array, but the greatest interest at present is in arrays of short vertical antennas. A vertical has an omnidirectional horizontal pattern, but when two or more are combined in an array, the spacing and phasing creates a directive pattern that can have very high performance. Figure 10 shows the horizontal pattern of a reduced-size 4-square array—100 feet per side on 160M. This is an excellent pattern that virtually eliminates signals and noise from the rearward direction.

Interested hams are directed to these key references for more information on receive antennas:

ARRL Antenna Book (any recent edition, or perhaps multiple editions since content changes over time)

Low Band DXing by ON4UN (4th or 5th editions have the most data)

Inserting Accessory Devices in the Receive Path

A valuable use of the Antenna IN/OUT configuration is adding a preamplifier, attenuator or filter (see Figure 11) that offers performance not available in the receiver itself. Like an external antenna, these accessories augment the radio's basic performance with custom options for your own operating preferences.

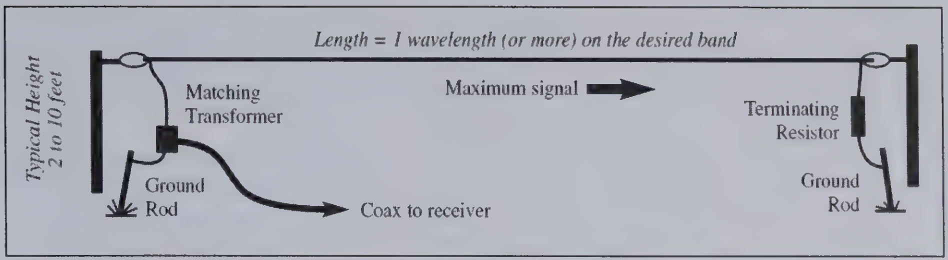


Figure 7—The Beverage antenna is a straightforward design with good directivity.

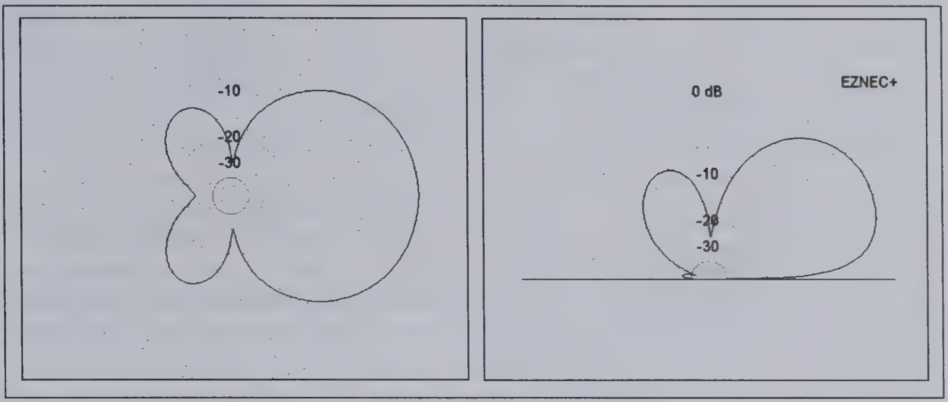


Figure 8—Beverage horizontal pattern (left) and vertical pattern (right).

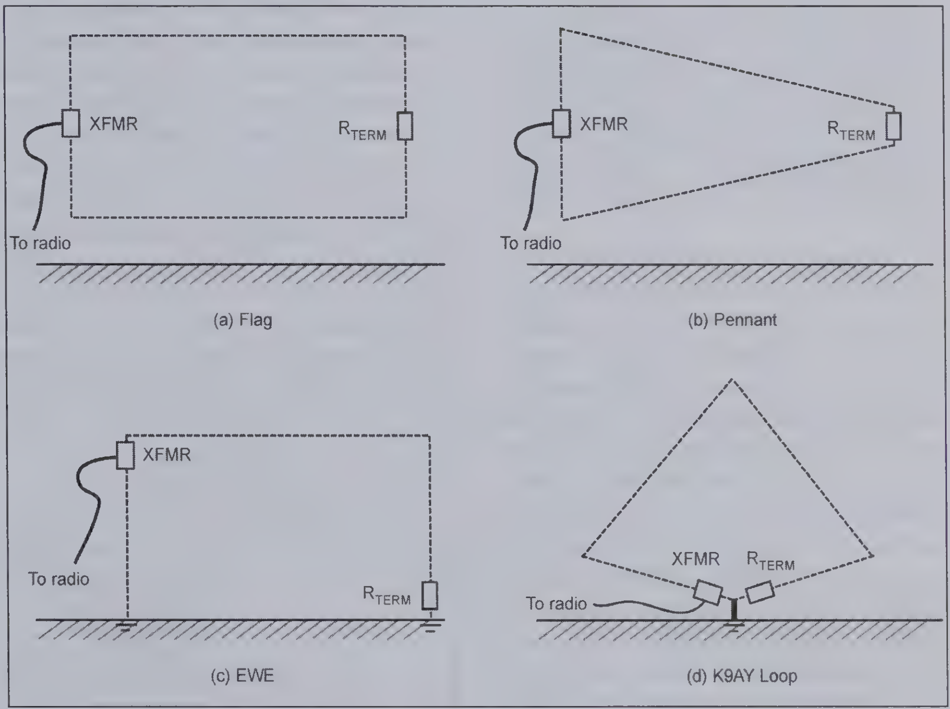


Figure 9—Terminated loop antennas have been developed in various configurations. The Flag and Pennant antennas do not require ground connection, which is useful when the ground conductivity is far from typical. The EWE and K9AY Loop include ground rods, which allows them to produce higher signal levels for the same size due to gain from the "ground image".

Preamplifiers—Your radio likely has an internal preamplifier, which is suitable for most hams' needs. However, you may want a different set of performance features than what is offered by the manufacturer, such as higher gain, lower noise figure, or higher dynamic range.

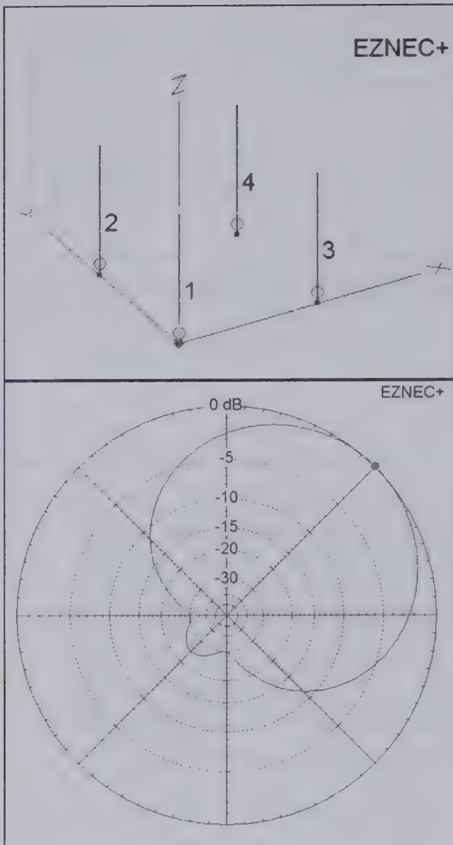


Figure 10—A 4-square array of short verticals is an example of high performance antenna system with an excellent directive pattern.

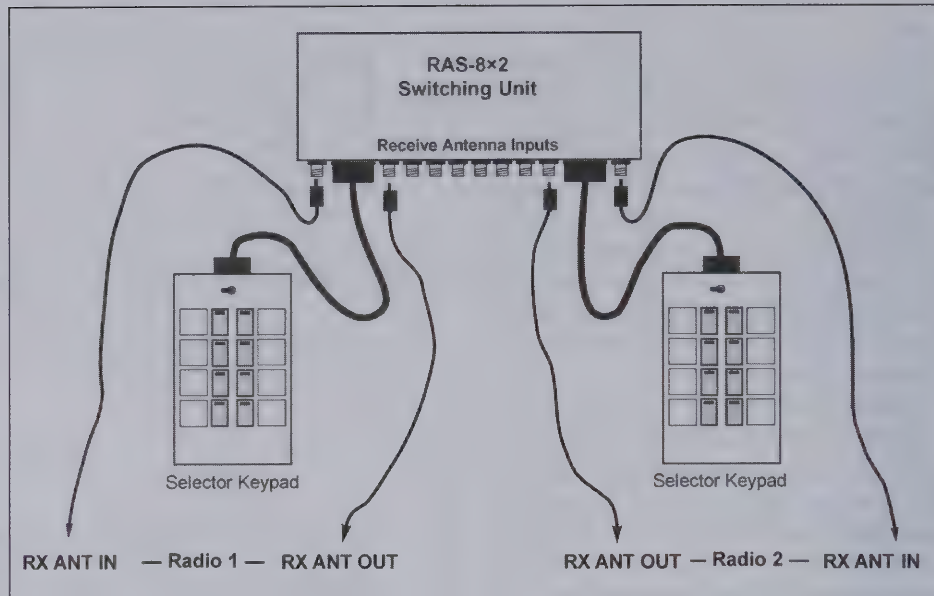


Figure 11—An more complex switching and routing system expands a radio's usefulness, connected via the RX ANT IN/OUT ports.

Attenuators—Very few commercial radios offer more than one attenuation option, typically 10 dB. But when listening on a transmit antenna for 160M, the ambient noise might be 30 or 40 dB above the receiver's own noise floor. Such strong noise, in combination with the radios' AGC circuit, will mask signals that would otherwise be heard well. Attenuating the noise to a level only slightly above the receiver noise floor will allow the AGC to operate normally—on signals only, not noise—and will allow the radio to operate with its best dynamic range.

Filters—Many commercial radios use a wideband up/down conversion scheme that does not have much front end selectivity. Adding a bandpass filter can help reduce intermods from strong out-of-band signals. Also, when operating contests or searching for DX, some hams use two or more radios to operate on more than one band at a time. A good filter will reduce interference and the possibility of front end damage when transmitting on another band.

Often, the above accessories are used in combination with one another (I have preamps with built-in filters, for example). They may also be used with the receive antennas noted earlier. This brings us to the next example: custom routing and switching of external antennas and devices. My own station has a switching unit with inputs for eight receive antennas, and includes preamplifiers with integrated bandpass filters. I also make and sell similar switching systems for other hams, so I know there are at least a couple hundred stations around the world that are equipped similarly! Figure 11 shows how such a system works with two radios (or a single radio with a sub-receiver). This type of flexible switching is extremely valuable—I originally designed it for contest operation, but quickly realized that it was effective at any time. Hearing QRP signals is always easier when your station is operating at peak performance!

The Wrap-Up

Many of us are aware of the gain, pattern and benefits of height for our antennas. And we work hard to understand the performance of our radios. We get high quality keyers and paddles, we use spectrum displays and the latest modeling and simulation software. We want our stations to work well!

We don't always pay attention to how all these things work together. This talk described just one aspect of flexible station operation: the receiver signal path. Hopefully, it will start you thinking about your operating style, and how to make all the pieces at your station operate together smoothly and efficiently.

Reminder! FDIM is May 14-17, 2015!

QRP ARCI's Four Days in May will again be held at the Holiday Inn – Fairborn, Ohio, at the same time as the nearby Dayton Hamvention®.

Make your travel plans now, and watch for hotel and program information on the club website — www.qrparci.org — and an announcement in the next issue (January 2015) of *QRP Quarterly*.

See you at FDIM 2015!

QRP Contests

Jeff Hetherington—VA3JFF

contest@qrparci.org

We are quickly coming to the end of another year. 2014 has flown by quickly, and we are now preparing for 2015 in many aspects of our lives. Our hobbies are no different and, like many of you, I am now marking my calendar for the operating events and contests that I would like to participate in for the coming year. You had your chance to give us your feedback for the coming year's contests, and I am excited to announce that QRP ARCI will once again sponsor 12 events for 2015! Many of your favourite contests will return unchanged, and a few of the sprints will be retired for now in order to run something with a different theme. For 2015, we will have three new sprints, the New Year Sprint on January 3rd, the Spring Digital Sprint on March 13th and the Slow Speed Sprint on August 22nd. These sprints will all follow our standard format, so the existing contest logging software will all work without needing any updates or reprogramming. Retired for now will be the Pet Rock Celebration, Grid Square Sprint and Welcome to QRP Contest. Get on the air, tell your friends, and lets show the world just what can be done when QRPers unite to find each other on the air!

This quarter featured three contests with a combination of familiar callsigns and a few new comers claiming top scores and bragging rights. The QRP Shoot Out is a unique contest that calls on the participants to show how skilled they are at both CW and SSB contesting. Saturday is the CW sprint and Sunday is the SSB sprint. There were two members that were up to that challenge and in the end, Harold Slack, VE5BCS managed 4,312 points to easily outdistance runner-up Gary Agranat, WA2JQZ who totaled 392 points.

For the Summer Homebrew Sprint, there was a bit more participation and a few impressive scores! Returning to top spot was Randy Foltz, K7TQ with 35,260 points! It has been a while since Randy took top honours in a contest, and it is nice to see him return to the top of the charts. In a real close battle, John T. Laney III, K4BAI topped Bob Patten, N4BP for second and third place respectively with 18,788 points and 17,346 points. More impressive was the fact that both John and Bob used commercial rigs and claimed zero bonus points. Rounding out the top 5, was Curt Hulett, KB5JO with 10,800 points and Donald Younger, W2JEK with 10,189 points.

The final contest this quarter was the Welcome to QRP Contest, which will be retired after this year. Claiming his second win of the quarter was Harold Slack, VE5BCS with 5,231 points. Another 2nd place finish was achieved by John Laney, K4BAI with 2,296 points, while Charles Hooker, VE3CQH took third place honours with 840 points. The top five was finished off with a 4th place tie between Phillip Bowers, KBØETU and Scott McMullen W5ESE. All participants this year were experienced, and there were no new comers to submit logs.

Until next time, keep your power down and your QSO rates up.

—73/72, Jeff, VA3JFF

Mark Your Calendars for these QRP ARCI Contests:

27 November 2014 — Top Band Sprint
14 December 2014 — Holiday Spirits Homebrew Sprint

2015 Contests

3 January 2015 — New Years Sprint
25 January 2015 — Winter Fireside SSB Sprint
14 March 2015 — Spring Digital Sprint
4 & 5 April 2015 — Spring QSO Party
31 May 2015 — Hootowl Sprint
14 June 2015 — QRP Shootout
5 July 2015 — Summer Homebrew Sprint
22 August 2015 — Slow Speed Sprint
5 & 6 September 2015 — The Two Side Bands Sprint
10 & 11 October 2015 — Fall QSO Party
3 December 2015 — Top Band Sprint
13 December 2015 — Holiday Spirits Homebrew Sprint

Visit www.qrparci.org for more contest information

Top 2 QRP Shootout	
Harold Slack, VE5BCS	4,312 Points
Gary Agranat, WA2JQZ	392 Points

Top 5 Summer Homebrew Sprint	
Randy Foltz, K7TQ	35,260 Points
John T. Laney III, K4BAI	18,788 Points
Bob Patten, N4BP	17,346 Points
Curt Hulett, KB5JO	10,800 Points
Donald Younger, W2JEK	10,189 Points

Summer Homebrew Sprint Soapbox

Slow first 3 hours with just 5 Qs/hr. Last hour picked up some. Had fun moving K7DD on 3 bands. —**K7TQ**

20m was up and down today. Only three Qs today. A couple others heard me, but not enough for a good contact. Running 800 mW from homebrew two transistor Tx. Lots of fun. —**KF7WNS**

Just didn't hear too mnay stations, but threw up the antenna at the last minute and it's probably pointed wrong. 2nd time in 20+ years I've operated the 1st was Field Day a week before. —**AB4LX**

My only QSO for this test was K7TQ. Condx were ruff so I did not hang around long!! —**VE7KBN**

Top 5 Welcome to QRP	
Harold Slack, VE5BCS	5,231 Points
John T. Laney III, K4BAI	2,296 Points
Charles Hooker, VE3CQH	840 Points
Phillip Bowers, KBØETU	140 Points
Scott McMullen, W5ESE	140 Points

2014 QRP SHOOTOUT RESULTS

Call	QTH	Bands	Class	Pwr	Qs	Pts	SPC	Mult	Bonus	Score
VE5BCS	SK	20	A1	< 5W	22	56	11	7		4312
WA2JQZ	AL	20	A1	< 5W	4	14	4	7		392

2014 SUMMER HOMEBREW SPRINT RESULTS

Call	QTH	Bands	Class	Pwr	Qs	Pts	SPC	Mult	Bonus	Score
K7TQ	ID	AB	A2	< 5W	26	109	20	7	20000	35260
K4BAI	GA	AB	A2	< 5W	30	122	22	7		18788
N4BP	FL	Hi	A2	< 5W	26	118	21	7		17346
KB5JO	TX	20	A1	< 1W	4	20	4	10	10000	10800
W2JEK	NJ	AB	A1	< 5W	3	9	3	7	10000	10189
AB8FJ	OH	AB	A1	< 5W	2	10	2	7	10000	10140
NO1R	NC	AB	A1	< 5W		57	11	7		4389
KF7WNS	OR	20	A1	< 1W	3	12	3	10	2000	2360
W9CC	IN	20	A1	< 5W	10	41	8	7		2296
AB4LX	GA	AB	A1	> 5W	5	22	5	1		110
VE7KBN	BC	20	A1	< 5W	1	5	1	7		35

2014 WELCOME TO QRP RESULTS

Call	QTH	Bands	Class	Pwr	Qs	Pts	SPC	Mult	Bonus	Score
VE5BCS	SK	20	A1	< 5W	4	11	3	7	5000	5231
K4BAI	GA	20	A2	< 5W	10	41	8	7		2296
VE3CQH	ON	20/40	A1	< 5W	6	24	5	7		840
KB0ETU	AL	20	A1	< 5W	2	10	2	7		140
W5ESE	TX	20	A1	< 5W	2	10	2	7		140

Welcome to QRP Soapbox

I'm not new to QRP but this was the first time in a farmer's field with CW, vertical antenna and battery power.—**VE5BCS**

Was QRL in the middle, but no one I worked (of only 10) seemed to actually know what contest we were in. —**K4BAI**

2015 QRP ARCI Contests

3 January 2015 — New Years Sprint
25 January 2015 — Winter Fireside SSB Sprint
14 March 2015 — Spring Digital Sprint
4 & 5 April 2015 — Spring QSO Party
31 May 2015 — Hootowl Sprint
14 June 2015 — QRP Shootout
5 July 2015 — Summer Homebrew Sprint
22 August 2015 — Slow Speed Sprint
5 & 6 September 2015 — The Two Sidebands Sprint
10 & 11 October 2015 — Fall QSO Party
3 December 2015 — Top Band Sprint
13 December 2015 — Holiday Spirits Homebrew Sprint

Visit www.qrparci.org for more contest information

UNITED STATES POSTAL SERVICE® **Statement of Ownership, Management, and Circulation (All Periodicals Publications Except Requester Publications)**

1. Publication Title	2. Publication Number	3. Filing Date
QRP Quarterly	1 5 5 1 - 1 5 3 7	September 26, 2014
4. Issue Frequency	**5. Number of Issues Published Annually**	**6. Annual Subscription Price**
Quarterly - four times per year	Four	\$25.00 USA \$28.00 Other

7. Complete Mailing Address of Known Office of Publication *(Not printer) (Street, city, county, state, and ZIP+4®)*
AY Technologies LLC, 3300 State Road 78, Mount Horeb, WI 53572-1320
Contact Person: Gary A. Breed
Telephone *(Include area code)*: 608-437-1200

8. Complete Mailing Address of Headquarters or General Business Office of Publisher *(Not printer)*
AY Technologies LLC, 3300 State Road 78, Mount Horeb, WI 53572-1320

9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor *(Do not leave blank)*

Publisher *(Name and complete mailing address)*
Gary A. Breed, P.O. Box 43, Mount Horeb, WI 53572-0043

Editor *(Name and complete mailing address)*
Timothy Stabler, 6420 Portage Ave., Portage, IN 46368-2249

Managing Editor *(Name and complete mailing address)*
Gary A. Breed, P.O. Box 43, Mount Horeb, WI 53572-0043

10. Owner *(Do not leave blank. If the publication is owned by a corporation, give the name and address of the corporation immediately followed by the names and addresses of all stockholders owning or holding 1 percent or more of the total amount of stock. If not owned by a corporation, give the names and addresses of the individual owners. If owned by a partnership or other unincorporated firm, give its name and address as well as those of each individual owner. If the publication is published by a nonprofit organization, give its name and address.)*

Full Name	Complete Mailing Address
AY Technologies LLC	P.O. Box 43, Mount Horeb, WI 53572-0043
Gary A. Breed	P.O. Box 43, Mount Horeb, WI 53572-0043

11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. If none, check box → ☒ None

Full Name	Complete Mailing Address

12. Tax Status *(For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one)*
The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes:
☐ Has Not Changed During Preceding 12 Months
☐ Has Changed During Preceding 12 Months *(Publisher must submit explanation of change with this statement)*

PS Form **3526**, July 2014 *[Page 1 of 4 (see instructions page 4)]* PSN: 7530-01-000-9931 **PRIVACY NOTICE:** See our privacy policy on *www.usps.com*.

13. Publication Title			14. Issue Date for Circulation Data Below	
QRP Quarterly			Summer 2014	
15. Extent and Nature of Circulation			**Average No. Copies Each Issue During Preceding 12 Months**	**No. Copies of Single Issue Published Nearest to Filing Date**
a. Total Number of Copies *(Net press run)*			2040	1970
b. Paid Circulation *(By Mail and Outside the Mail)*	(1)	Mailed Outside-County Paid Subscriptions Stated on PS Form 3541 (Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)	1615	1539
	(2)	Mailed In-County Paid Subscriptions Stated on PS Form 3541 *(Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)*	7	5
	(3)	Paid Distribution Outside the Mails Including Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid Distribution Outside USPS®	20	21
	(4)	Paid Distribution by Other Classes of Mail Through the USPS (e.g., First-Class Mail®)	324	311
c. Total Paid Distribution *[Sum of 15b (1), (2), (3), and (4)]* ▶			1966	1876
d. Free or Nominal Rate Distribution *(By Mail and Outside the Mail)*	(1)	Free or Nominal Rate Outside-County Copies included on PS Form 3541	0	0
	(2)	Free or Nominal Rate In-County Copies Included on PS Form 3541	0	0
	(3)	Free or Nominal Rate Copies Mailed at Other Classes Through the USPS (e.g., First-Class Mail)	22	23
	(4)	Free or Nominal Rate Distribution Outside the Mail *(Carriers or other means)*	27	26
e. Total Free or Nominal Rate Distribution *(Sum of 15d (1), (2), (3) and (4))*			49	49
f. Total Distribution *(Sum of 15c and 15e)* ▶			2015	1925
g. Copies not Distributed *(See Instructions to Publishers #4 (page #3))* ▶			25	45
h. Total *(Sum of 15f and g)*			2040	1970
i. Percent Paid *(15c divided by 15f times 100)* ▶			97.6%	97.5%

* If you are claiming electronic copies, go to line 16 on page 3. If you are not claiming electronic copies, skip to line 17 on page 3.

16. Electronic Copy Circulation	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Paid Electronic Copies ▶		
b. Total Paid Print Copies (Line 15c) + Paid Electronic Copies (Line 16a) ▶		
c. Total Print Distribution (Line 15f) + Paid Electronic Copies (Line 16a) ▶		
d. Percent Paid (Both Print & Electronic Copies) (16b divided by 16c × 100) ▶		

☐ **I certify that 50% of all my distributed copies (electronic and print) are paid above a nominal price.**

17. Publication of Statement of Ownership
☒ If the publication is a general publication, publication of this statement is required. Will be printed in the Fall 2014 issue of this publication.
☐ Publication not required.

18. Signature and Title of Editor, Publisher, Business Manager, or Owner
Gary A. Breed, Publisher
Date: September 26, 2014

I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties).

**Your membership lasts forever—
but your subscription to *QRP Quarterly*
must be renewed!**

Go to the QRP ARCI web site and use the Online Member Lookup feature to keep track of your membership/subscription status:

http://www.qrparci.org/lookup.html

QRP ARCI takes membership applications and renewals via credit card—*online*—using the **PayPal** system. *We prefer it for all applicants—worldwide*! Go to the club web site:

http://www.qrparci.org/

and follow the instructions. Be sure to select the appropriate button for the area of the world you reside in (US, Canada, or DX). International members may send payment by check directly to the club Treasurer, but ... ***funds must be drawn on a U.S. bank and be in U.S. dollars.*** Make checks payable to: **QRP ARCI**.

When renewing, please enclose the mailing label from your *QRP Quarterly.* Send applications by mail to:

**QRP ARCI
Jack Nelson, K5FSE
1540 Stonehaven
Cumming, GA 30040**

Subscribe or Renew Now!
Don't Miss an issue of QRP Quarterly

Sign me up for a ❑ **NEW** / ❑ **RENEWAL** membership in QRP ARCI!

❑ **1 YEAR** ($25 US — US$28 Canada and Elsewhere)

❑ **2 YEARS** ($50 US — US$56 Canada and Elsewhere)

These amounts include active club member privileges and your QRP Quarterly subscription

Call ________________ QRP ARCI number (if renewal) ______________

Full Name ______________________________

Mailing Address ______________________________

City ______________________ State/Country ______________

Postal Code (ZIP+4 US) ______________________________

Previous Callsign(s) if any ______________________________

(The following information is optional; used only by QRP ARCI; not released to others)

E-mail address ______________________________

Comments ______________________________

____

Send check or money order to: **QRP ARCI
1540 Stonehaven
Cumming, GA 30040**

QRP Quarterly (ISSN #1551-1537, USPS #022-276) is published quarterly in January ("Winter"), April ("Spring"), July ("Summer") and October ("Fall") by AY Technologies LLC, 3300 State Road 78, Mount Horeb, WI, 53572. Periodical postage paid at Mount Horeb, WI and at additional mailing offices.

POSTMASTER: Send address corrections to QRP Quarterly, P.O. Box 43, Mount Horeb, WI 53572-0043. Subscription information: (608) 437-1200.

Subscription prices (all in U.S. dollars): Domestic one year $25, two years $50; Canada and elsewhere one year $28, two years $56.

QRP Quarterly is the official publication of the QRP Amateur Radio Club International (QRP ARCI), which is responsible for all editorial content. Editorial submissions should be sent to the Editor or an Associate Editor. See the staff listing on page 3 of each issue. Membership/subscription inquiries should be sent by e-mail to: secretary@qrparci.org, or by mail to QRP ARCI,1540 Stonehaven, Cumming, GA 30040.

This magazine is published under agreement with QRP ARCI by AY Technologies LLC — Mailing address: P.O. Box 43, Mount Horeb, WI 53572-0043.


ELECRAFT
KX3
ELECRAFT KX3 TRANSCEIVER
160-6 m (internal 2 m option planned)
SSB/CW/AM/FM/DATA modes
10 W output (100 W with KXPA100 amp)
World-class receive performance
Built-in advanced 32-bit DSP
Supports PC-based remote control and logging; SDR applications via RX I/Q outputs; simple firmware updates
Factory-assembled or easy-to-build, no-soldering kit; manual written with first-time HF users in mind
1.7″ x 3.5″ x 7.4″ (4.3 cm x 8.9 cm x 18.8 cm) 1.5 pounds (less options and 8-AA cell battery pack)
Current drain as low as 150 mA; 9-15 V DC
The Revolutionary KX3 All-Band/All-Mode Transceiver
Our new KX3 is a competition-grade transceiver that literally puts the world in the palm of your hand. With its large display, rich control set, and adjustable operating angle, the ultra-compact KX3 is equally at home on your desktop, in a vehicle, or in remote field locations. It's a true software-defined radio (SDR), with dual watch, noise reduction, digital voice recorder, RX/TX EQ, VOX, split-band speech compression, and CW keyer. The built-in PSK31 and RTTY modes work with or without a computer. Add the internal ATU, battery pack, and roofing filters for unmatched portability *and* performance.
ELECRAFT®
For complete features and specifications, go to www.elecraft.com